Goals for today from Estuary Subcommittee

- Key decisions that will allow us to move forward on report

- Consensus on:
  1. Un-sound Ecological Environment –Nueces Bay/Delta
  2. Freshwater Inflow Regime and Attainment based on indicator species

Sound Ecological Environment

Sound Ecological Environment

"A schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies."

- According to SAC guidance (SAC 2009a), a sound ecological environment is one that:
  - sustains the full complement of native species in perpetuity,
  - sustains key habitat features required by these species,
  - retains key features of the natural flow regime required by these species to complete their life cycles, and
  - sustains key ecosystem processes and services, such as elemental cycling and the productivity of important plant and animal populations.

- **1.2M cu yd from Nueces Bay ’58 alone (probably and underestimate)**

- **30’s oyster harvest ended → shell harvest → considered totally fished out (live and substrate) by 1967**

- **300’ rule but dredgers took advantage of “live” reefs during drought years of ‘50 and 60 ‘s**

Table 2-1: Summary of mean annual flow of the Nueces River into the Nueces Estuary (1940 to 1996)[1] and upper Nueces Delta (1940 to 1999)[2]. Time periods in both studies were based upon the construction dates of large reservoirs in the watershed.

Time Period	Mean annual river flow into Nueces Estuary (acre-ft)	Percent change from Period I	Mean annual river flow into upper Nueces Delta (acre-ft)	Percent change from Period I
1940-1957	619,000	—	127,997	—
1958-1982	614,000	-0.8%	77,989	-39.1%
1983-1996(9)	279,000	-54.9%	537	-99.6%

[1] Source: Asquith *et al.* 1997.
[2] Source: Irlbeck and Ward 2000.

Note: 1 acre-ft = 1.2336 10^3 m^3

- **1958 – Lake Corpus Christi → 1 Overbanking per year**
- **1982 –Choke Canyon Reservoir → 1 Overbanking every 3 years**
- **Major modifications and channelization of river preventing OB**

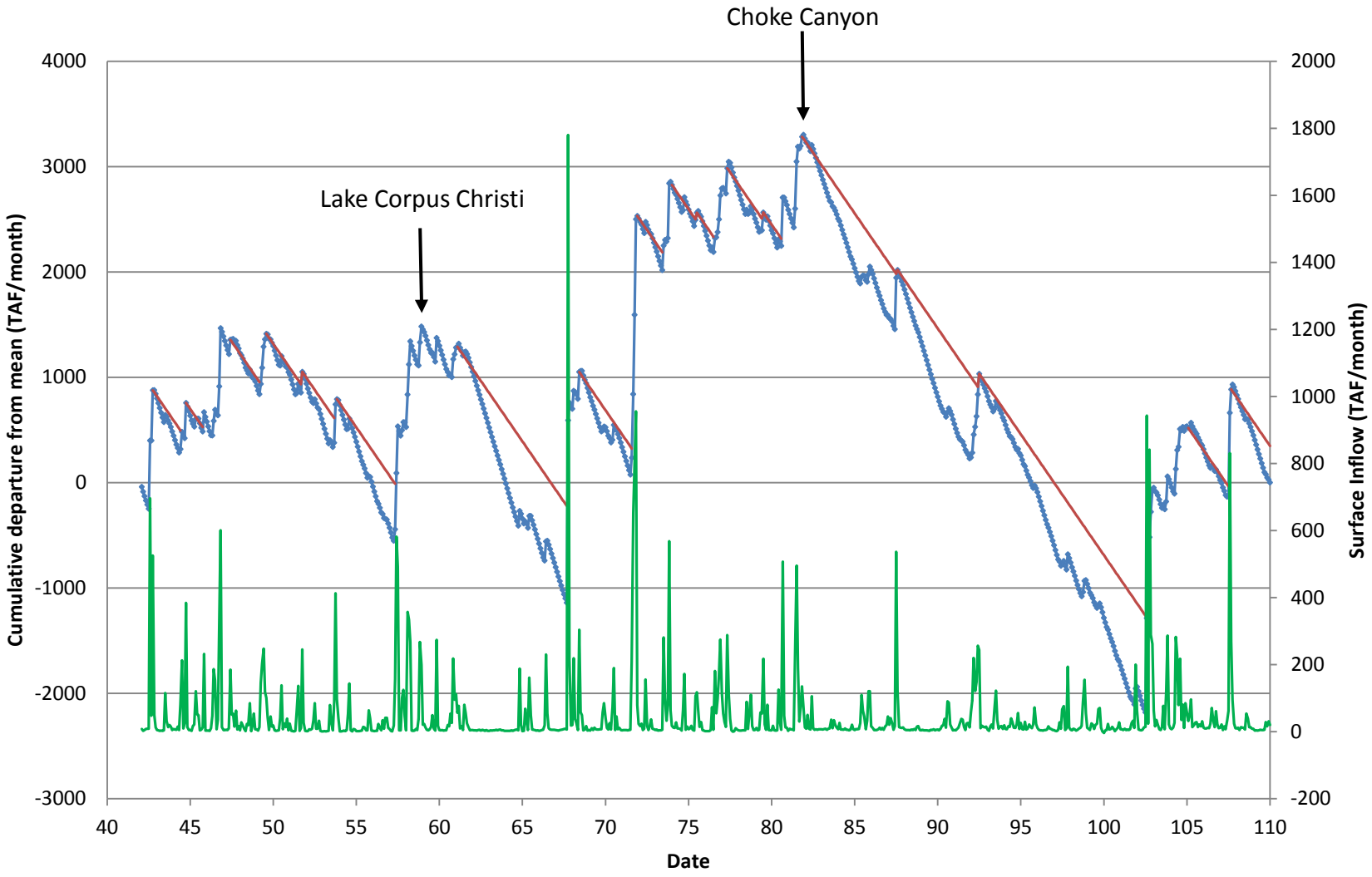


Figure X. Ruben's code

Key Indicator Species

Indicator Species Profiles

Species

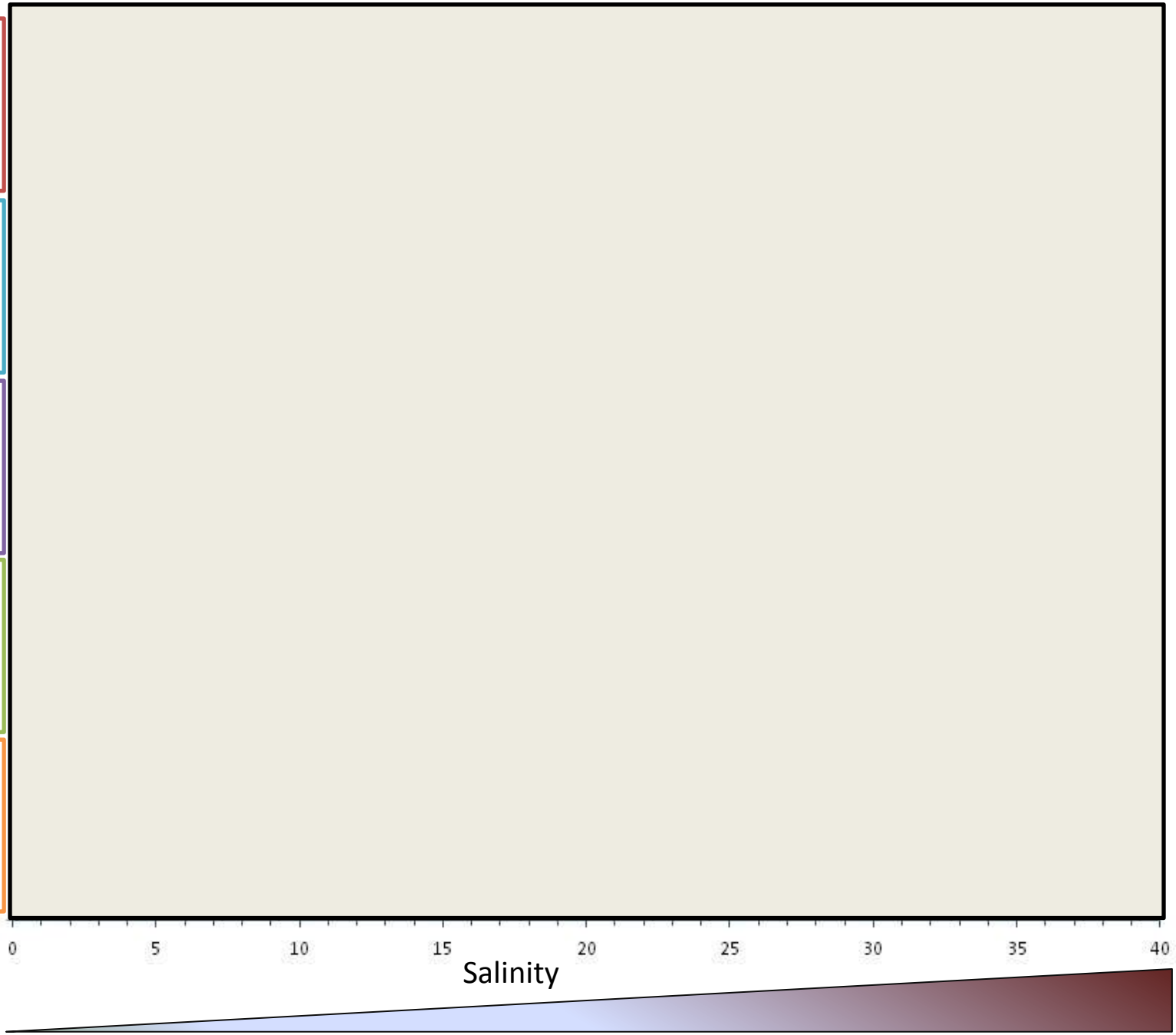
Spartina alterniflora

Benthic Infauna

Crassostrea virginica

Callinectes sapidus

Micropogonias undulatus

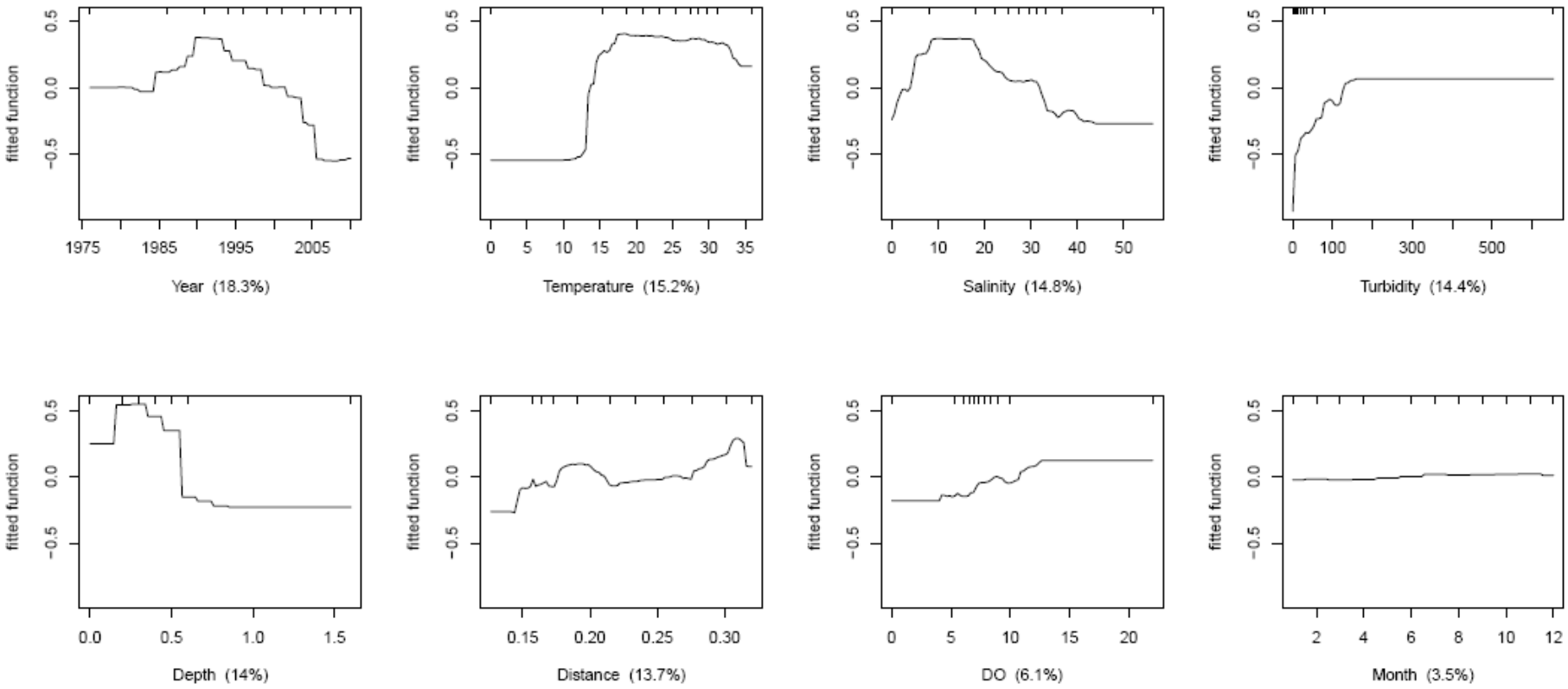


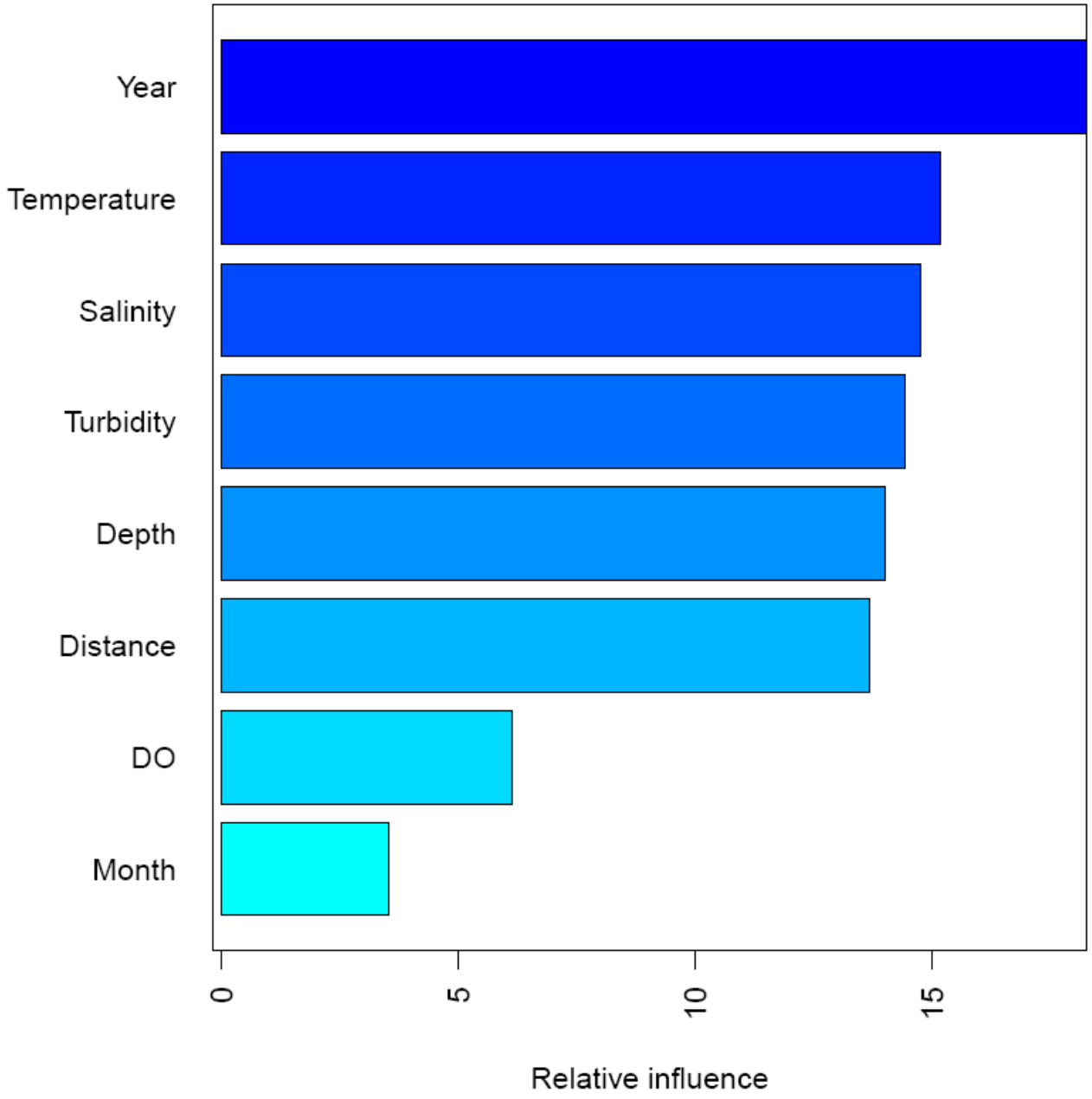
Boosted Regression Trees

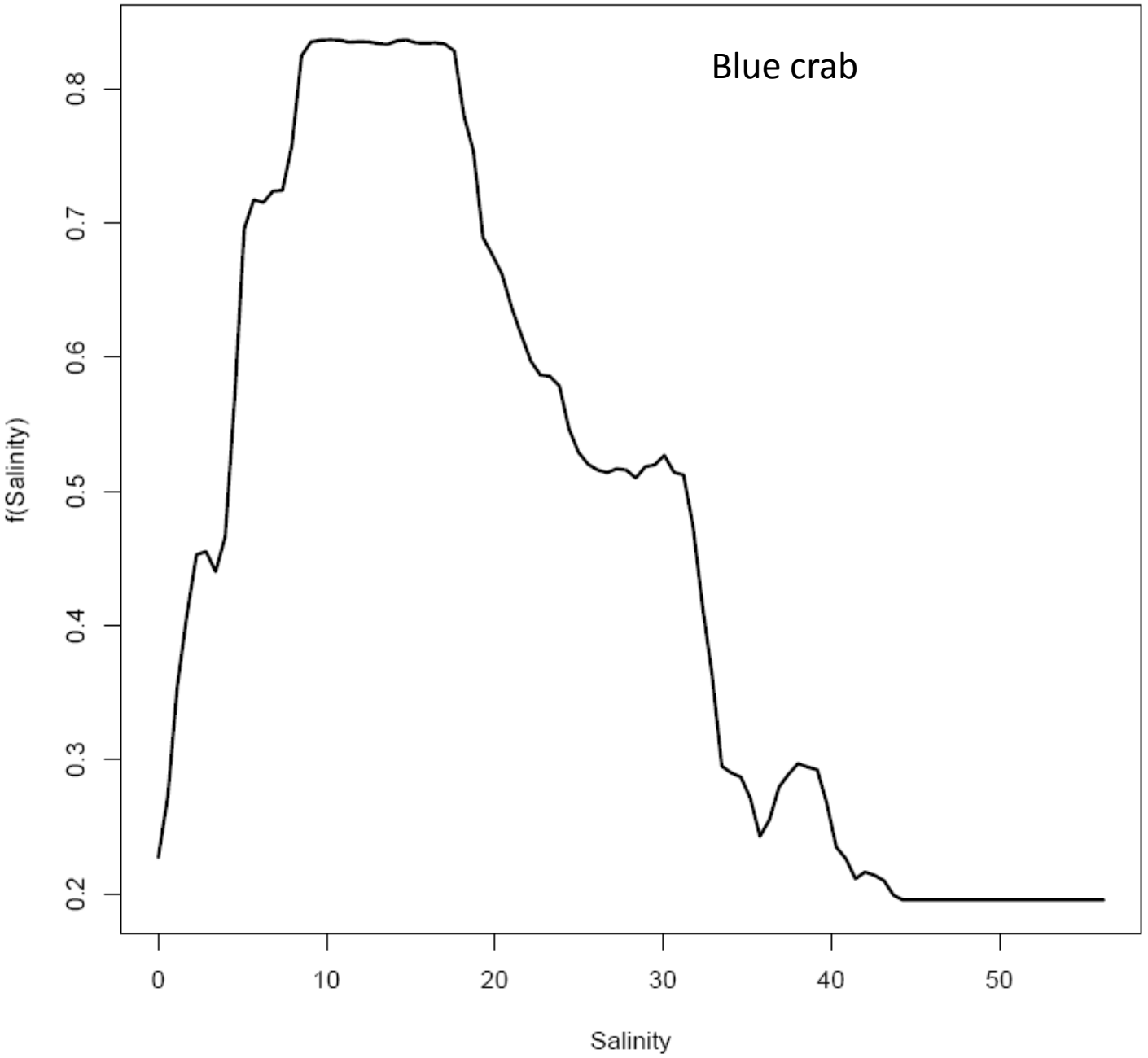
- Examined 31 Species

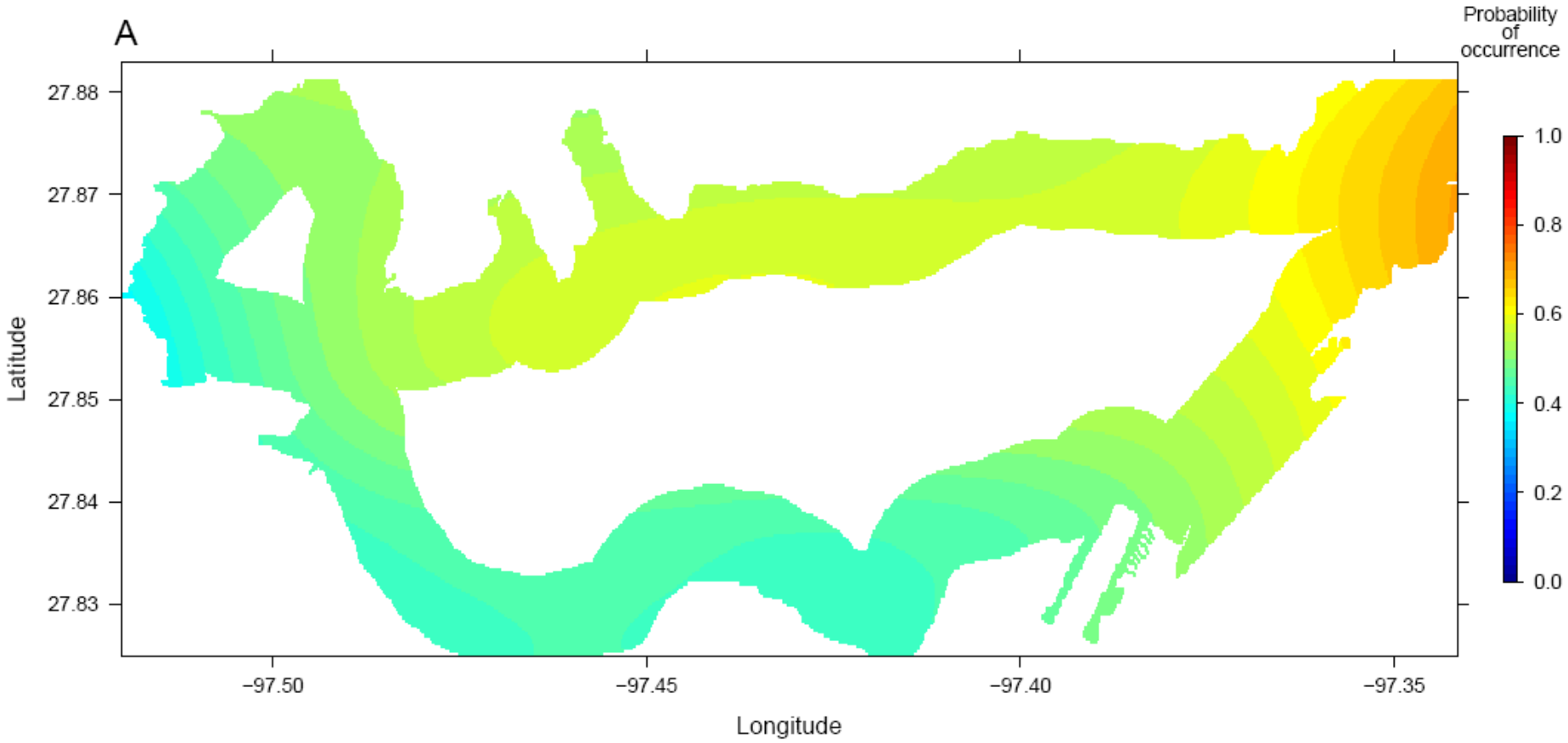
- Generated 2 key (i.e., “Best”) nektonic indicators of FWI

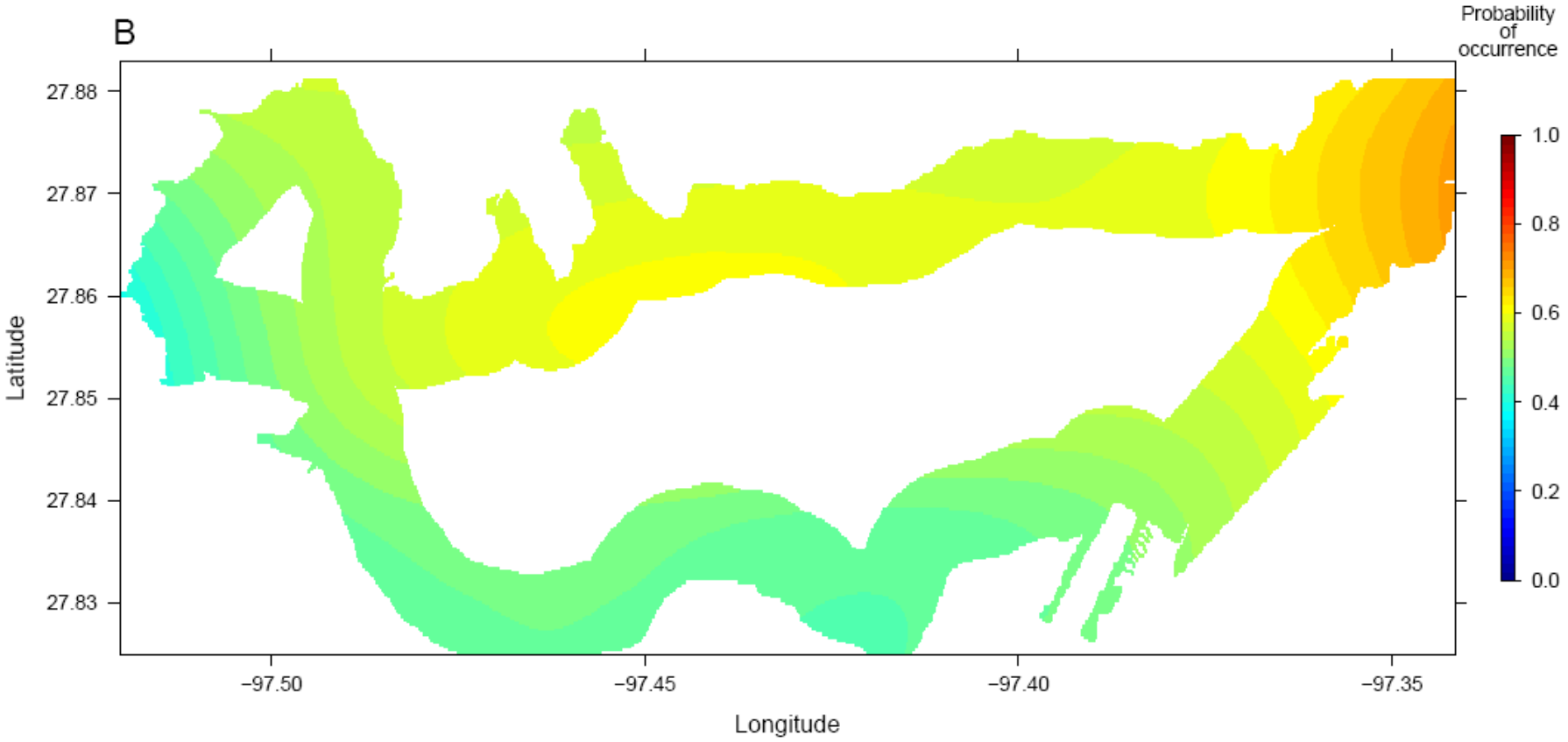
    1. blue crab
    2. Atlantic croaker


fitted function
0.5
0.0
−0.5
1975
1985
1995
2005
Year (18.3%)
0
5
10
15
20
25
30
35
Temperature (15.2%)
0
10
20
30
40
50
Salinity (14.8%)
0
100
300
500
Turbidity (14.4%)
0.0
0.5
1.0
1.5
Depth (14%)
0.15
0.20
0.25
0.30
Distance (13.7%)
0
5
10
15
20
DO (6.1%)
2
4
6
8
10
12
Month (3.5%)


Year
Temperature
Salinity
Turbidity
Depth
Distance
DO
Month
0
5
10
15
Relative influence


Blue crab
f(Salinity)
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
Salinity


A
Probability of occurrence
1.0
0.8
0.6
0.4
0.2
0.0
27.88
27.87
27.86
27.85
27.84
27.83
Latitude
−97.50
−97.45
−97.40
−97.35
Longitude


B
Probability of occurrence
1.0
0.8
0.6
0.4
0.2
0.0
27.88
27.87
27.86
27.85
27.84
27.83
Latitude
−97.50
−97.45
−97.40
−97.35
Longitude

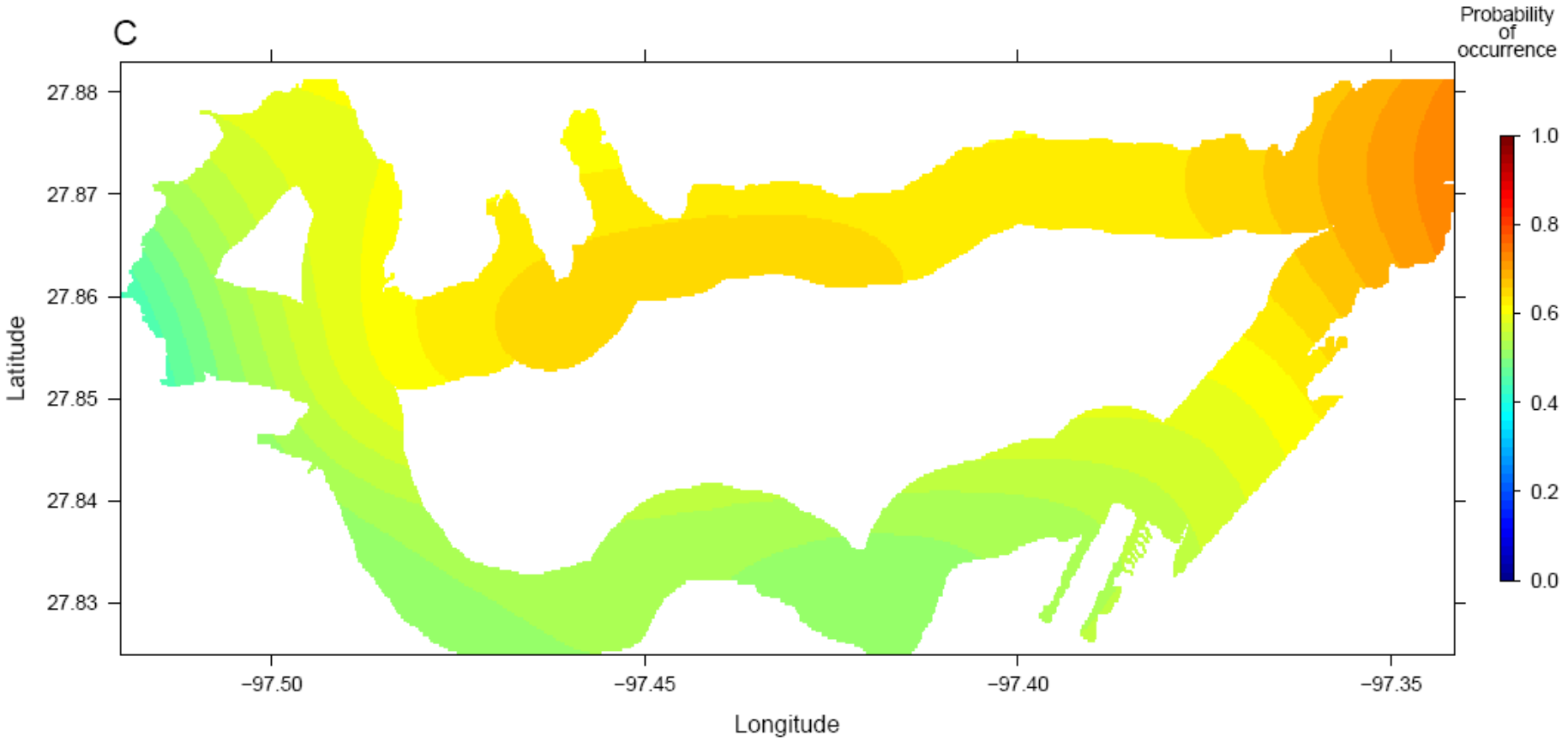
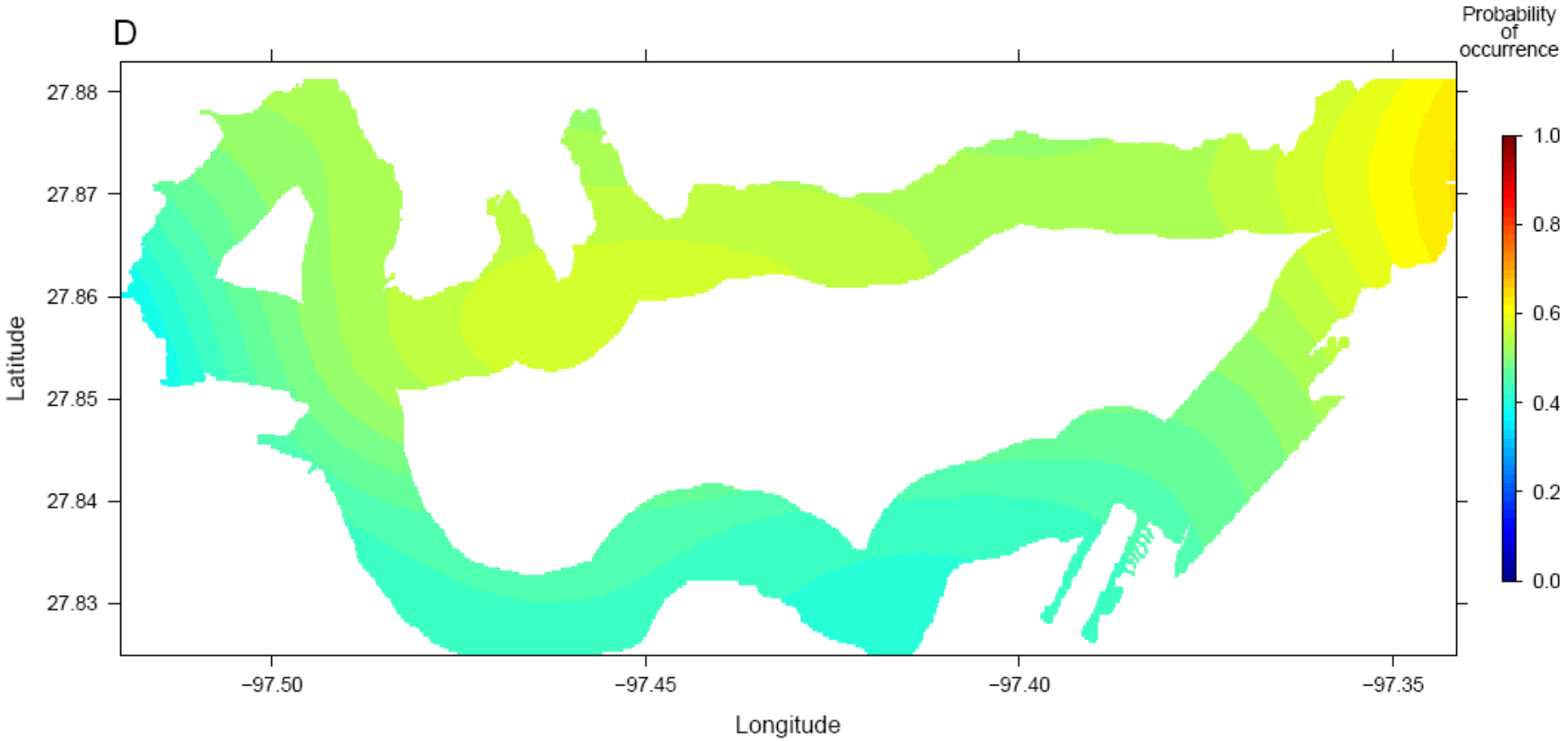
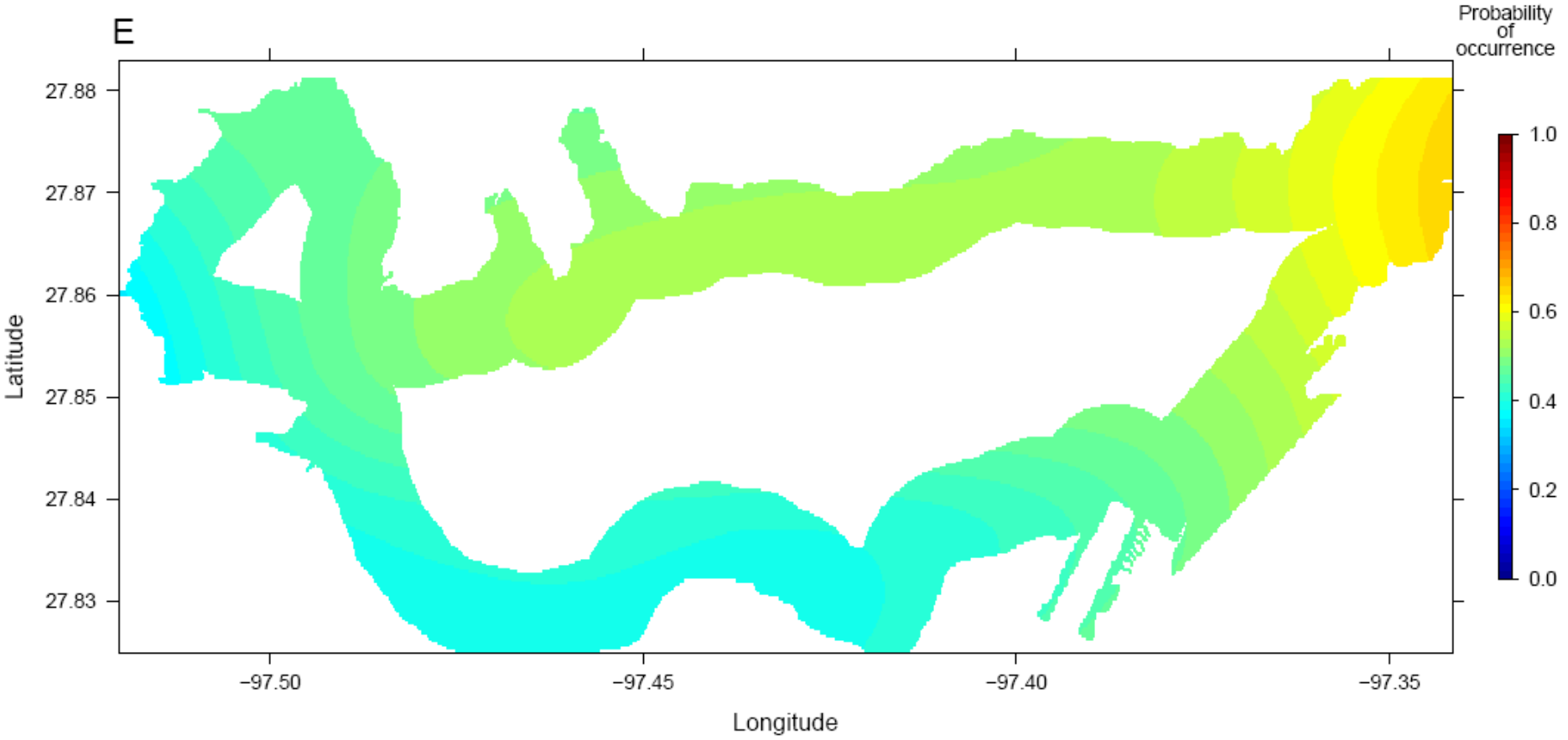


Figure X. Blue crab predicted frequency of occurrence salinity reduced 10 from mean


D
Probability of occurrence
1.0
0.8
0.6
0.4
0.2
0.0
27.88
27.87
27.86
27.85
27.84
27.83
Latitude
−97.50
−97.45
−97.40
−97.35
Longitude


E
Probability of occurrence
1.0
0.8
0.6
0.4
0.2
0.0
27.88
27.87
27.86
27.85
27.84
27.83
Latitude
−97.50
−97.45
−97.40
−97.35
Longitude

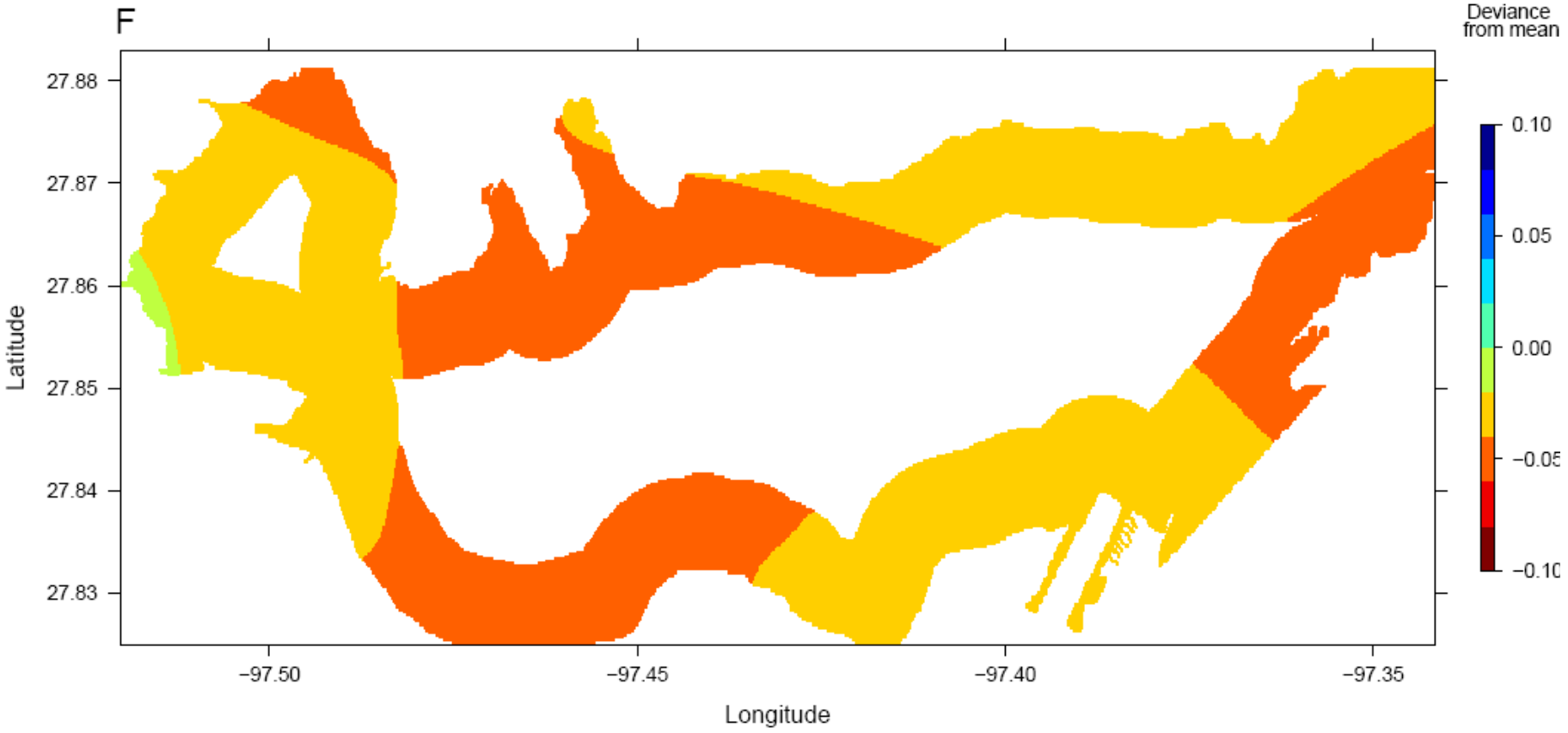
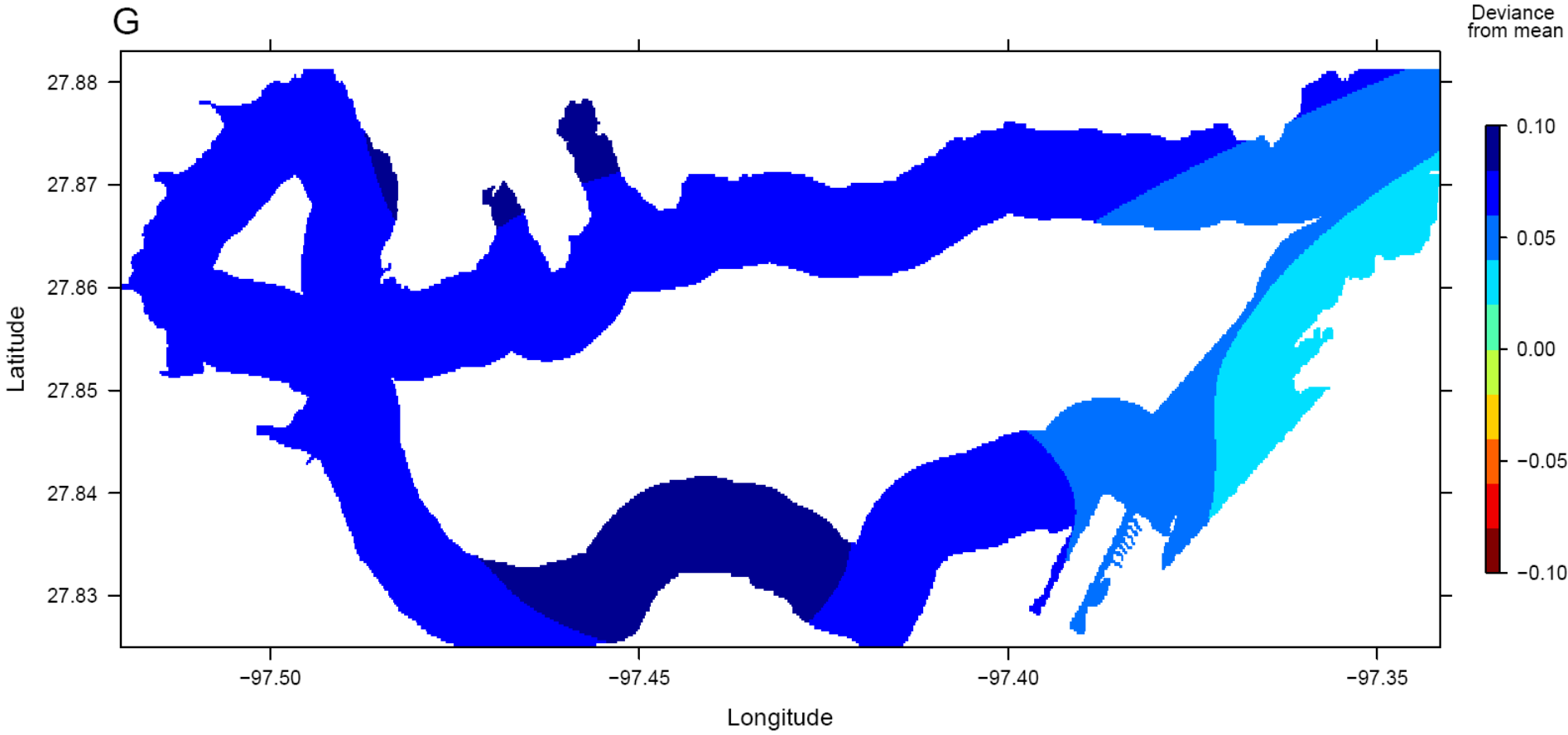
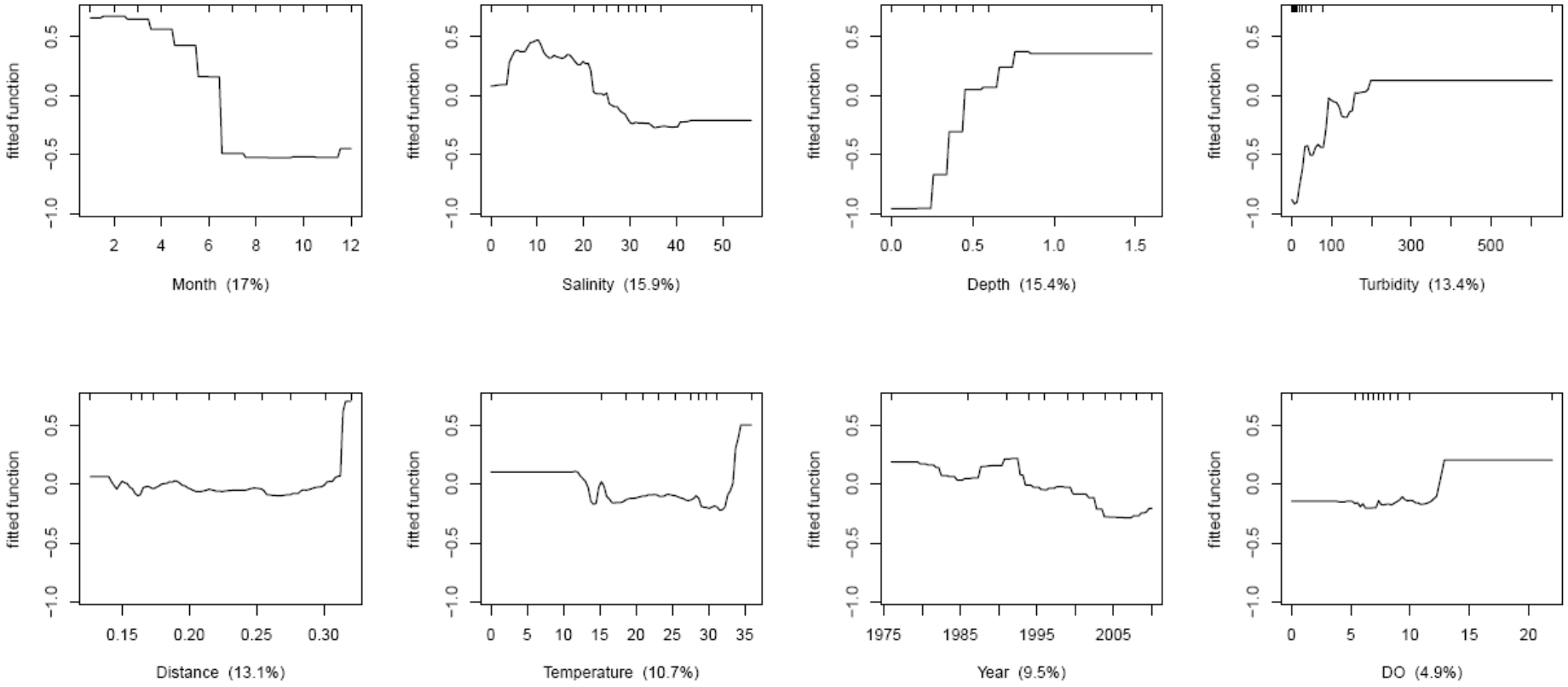


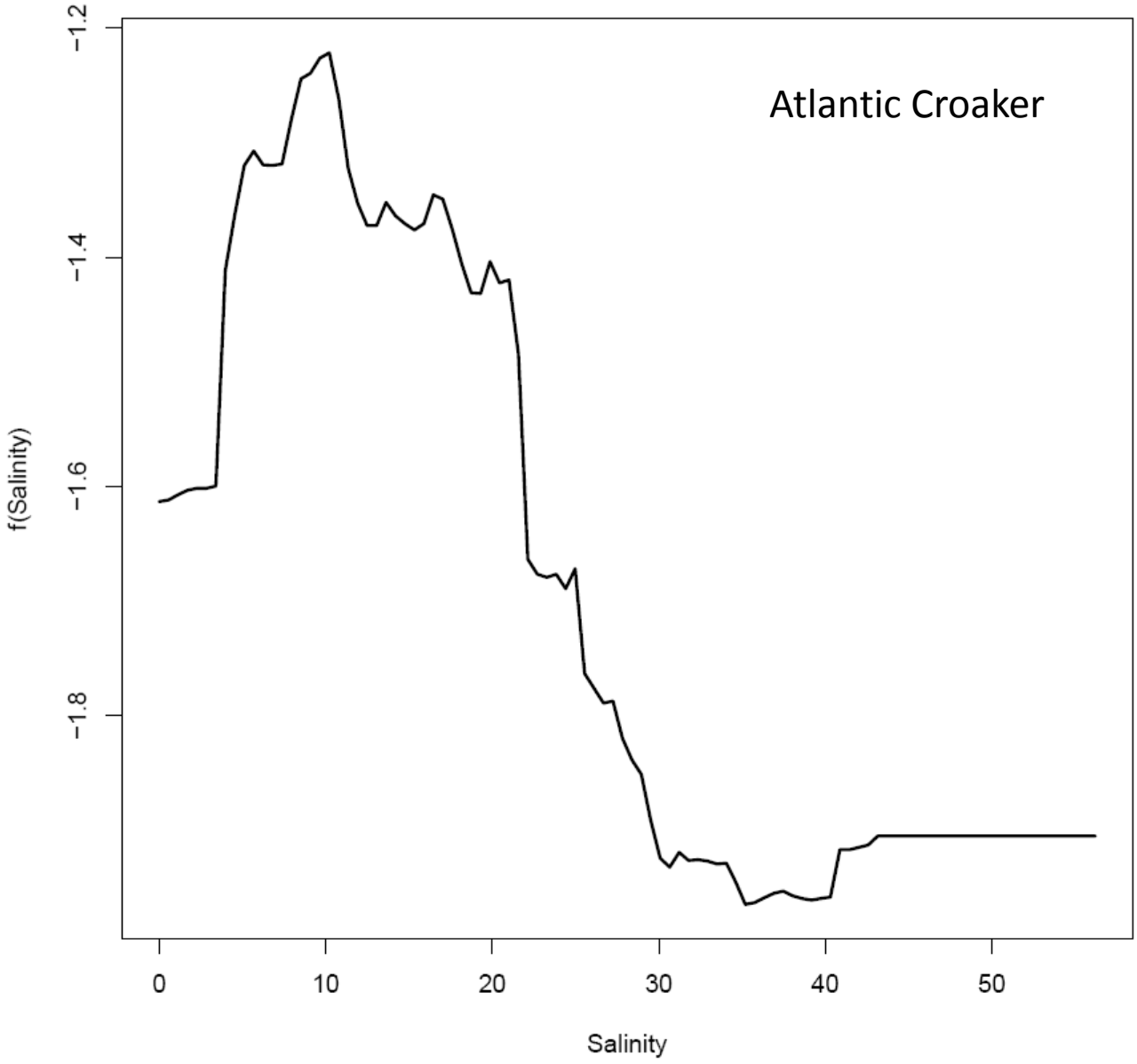
Figure X. Blue crab predicted frequency of occurrence salinity increased 10 from mean

Blue crab – deviance from mean
Salinity decreased 10 from mean

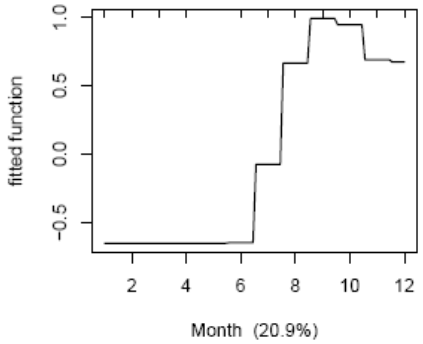


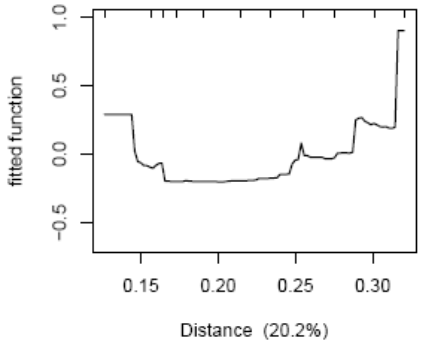
Atlantic Croaker

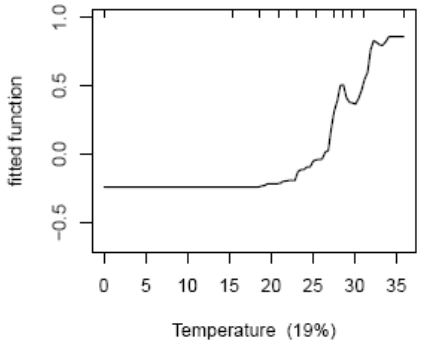


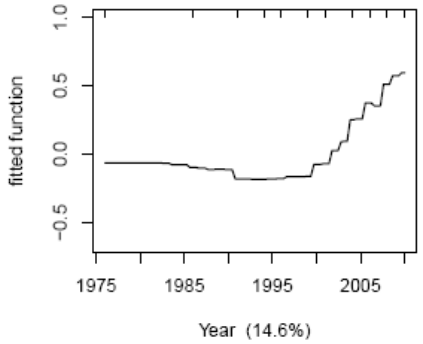

Atlantic Croaker
f(Salinity)
−1.2
−1.4
−1.6
−1.8
0
10
20
30
40
50
Salinity

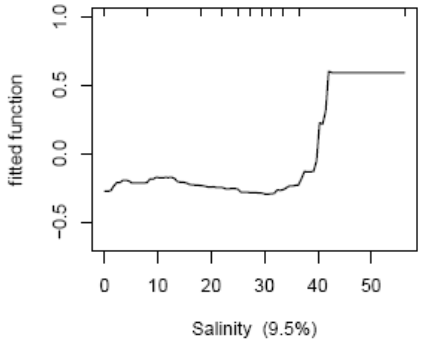
Spotfin mojarra

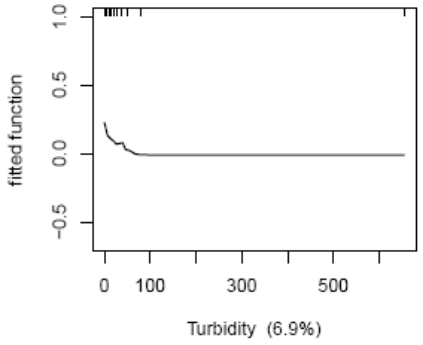


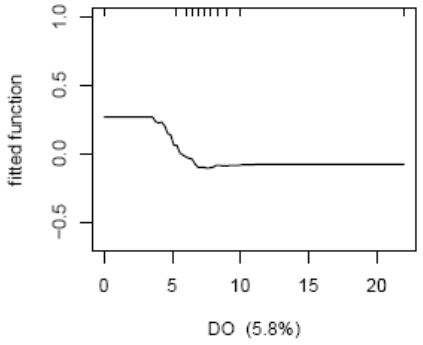


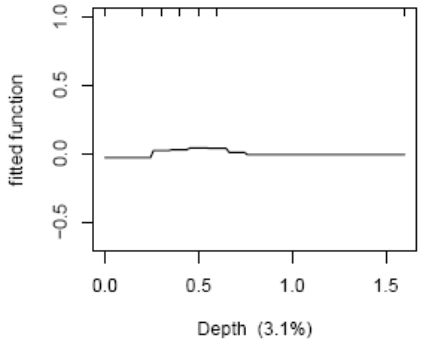




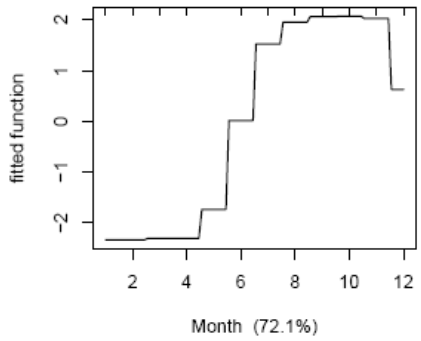


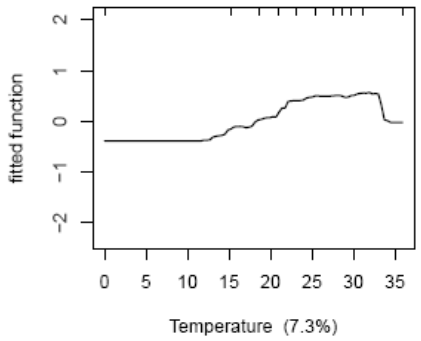


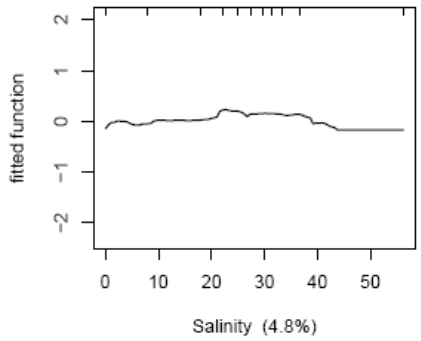


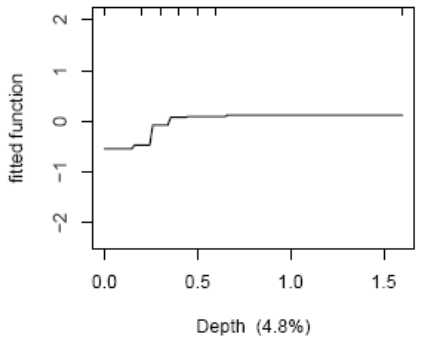


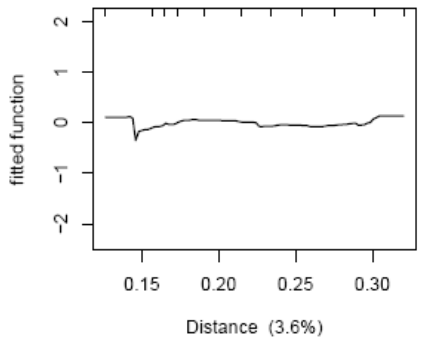
White shrimp

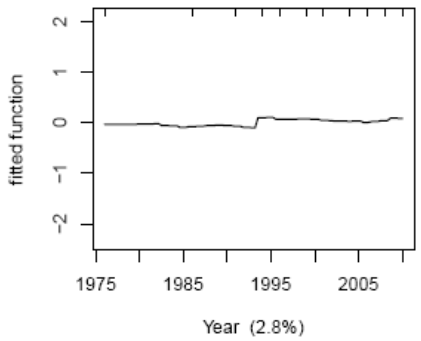


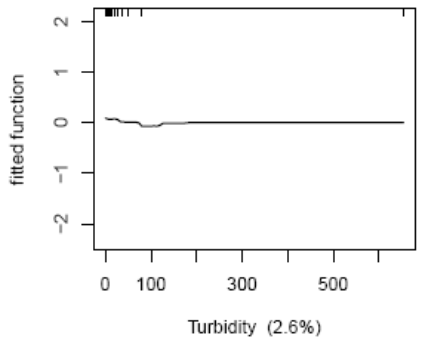


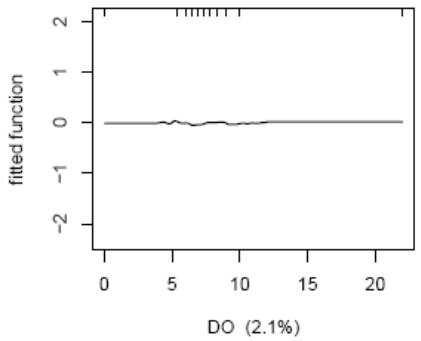












Indicator Species Profiles

Species

Spartina alterniflora

Benthic Infauna

Crassostrea virginica

Callinectes sapidus

Micropogonias undulatus

Smooth cordgrass
Salinity: 10-25

Infauna
(16-20)

Eastern Oyster
Salinity: 10-20

Blue crab
Salinity: 10-20

Atlantic croaker
Salinity: 8-22

0 5 10 15 20 25 30 35 40

Salinity

Freshwater Inflow Regime and Attainment

Condition (Target Salinity)	Nueces Estuary Freshwater Inflow Regime (Acre-Feet)												Recommendations		Historical Attainment		
	1 over-banking event per year: 3000 acre-ft (500 acre-ft per day for 6 days)												Annual Total	Attainment	1941-2009	1941-1982	1983-2009
High (10)	125,000 Acre-ft				250,000 Acre-ft				375,000 Acre-ft				750,000	25%	22%	26%	26%
Base (18)	22,000 Acre-ft				90,000 Acre-ft				60,000 Acre-ft				172,000	80%	67%	81%	44%
Subsistence (34)	5,000 Acre-ft				10,000 Acre-ft				15,000 Acre-ft				30,000	95%	94%	100%	85%
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct					
	Winter				Spring				Summer			Fall					

	Nueces River Flow (Acre-ft)			
Nueces Delta Porewater Target Salinity	22,000 (244/day)	90,000 (1000/day)	40,000 (444/day)	20,000 (222/day)
25	**Winter**	**Spring**	**Summer**	**Fall**

- We set target salinities based on indicator species salinity requirements for base condition. We then used TXBLEND model outputs for target salinities that correspond with high and subsistence conditions.

- We used the below regression from Nueces Bay inflow and SALT03 station to calculate freshwater inflow that would generate target salinities. However, based on marsh plant salinity requirements in the delta there needs to be an annual inflow of 172,000 acre-ft. Therefore, the bay-calculated inflow of 160,000 acre-ft was increased by an additional 12,000 acre-ft to meet base conditions for marsh plants. We also examined historical inflow regimes and determined what the inflow was 95% of the time during the full period of record (1941-2009). We used that inflow as the basis for the annual recommendation for subsistence conditions.

$$\text{Salinity} = 66.183 - (11.690 \times \text{Log}_{10}(\text{Inflow}))$$

- The allocation for seasonal inflow requirements were based on meeting the biological needs of all indicator species, while accounting for historical patterns of water availability.

- Attainment recommendations were based on historical inflow patterns and how often these conditions were met taking into consideration flow regime changes pre and post dam flows.

Indicator Species Profiles

Species

Spartina alterniflora

Benthic Infauna

Crassostrea virginica

Callinectes sapidus

Micropogonias undulatus

Smooth cordgrass
Salinity: 10-25

Infauna
(16-20)

Eastern Oyster
Salinity: 10-20

Blue crab
Salinity: 10-20

Atlantic croaker
Salinity: 8-22

0 5 10 15 20 25 30 35 40

Salinity

Condition (Target Salinity)	Nueces Estuary Freshwater Inflow Regime (Acre-Feet)												Recommendations		Historical Attainment		
	1 over-banking event per year: 3000 acre-ft (500 acre-ft per day for 6 days)												Annual Total	Attainment	1941-2009	1941-1982	1983-2009
High (10)	125,000 Acre-ft				250,000 Acre-ft				375,000 Acre-ft				750,000	25%	22%	26%	26%
Base (18)	22,000 Acre-ft				90,000 Acre-ft				60,000 Acre-ft				172,000	80%	67%	81%	44%
Subsistence (34)	5,000 Acre-ft				10,000 Acre-ft				15,000 Acre-ft				30,000	95%	94%	100%	85%
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct					
	Winter				Spring				Summer			Fall					

	Nueces River Flow (Acre-ft)			
Nueces Delta Porewater Target Salinity	22,000 (244/day)	90,000 (1000/day)	40,000 (444/day)	20,000 (222/day)
25	**Winter**	**Spring**	**Summer**	**Fall**

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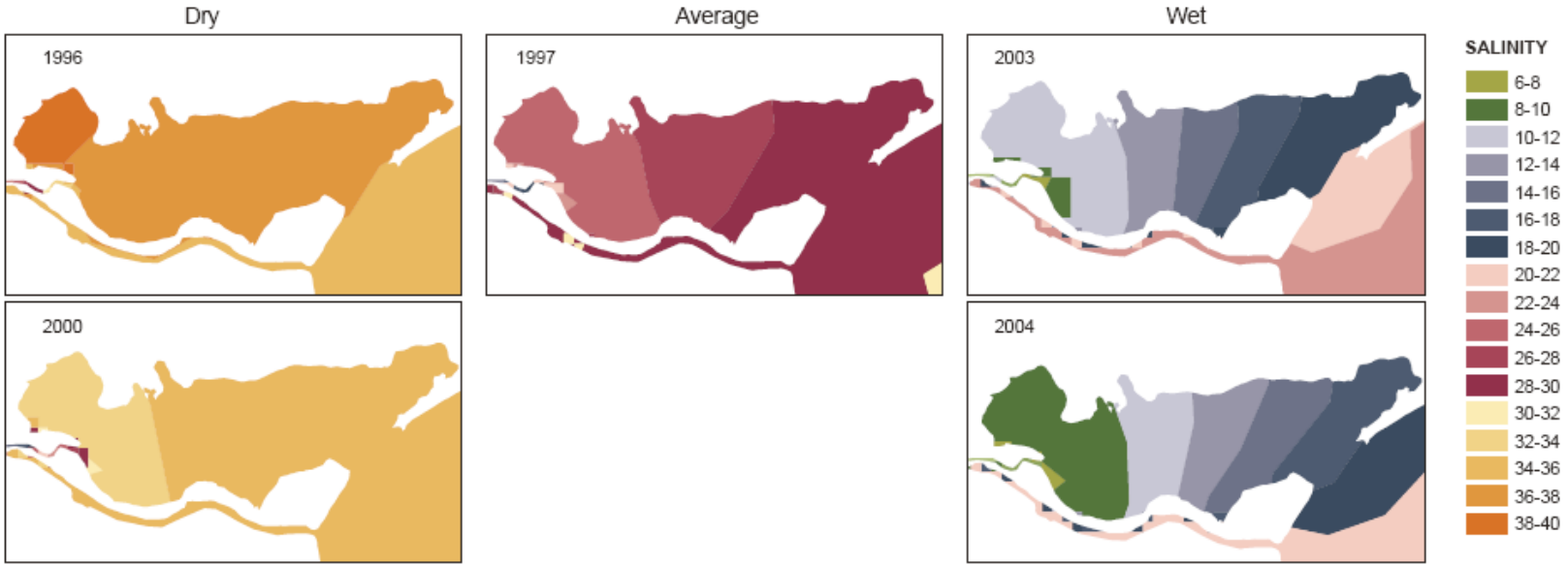
$$\text{Salinity} = 66.183 - (11.690 \times \text{Log}_{10}(\text{Inflow}))$$

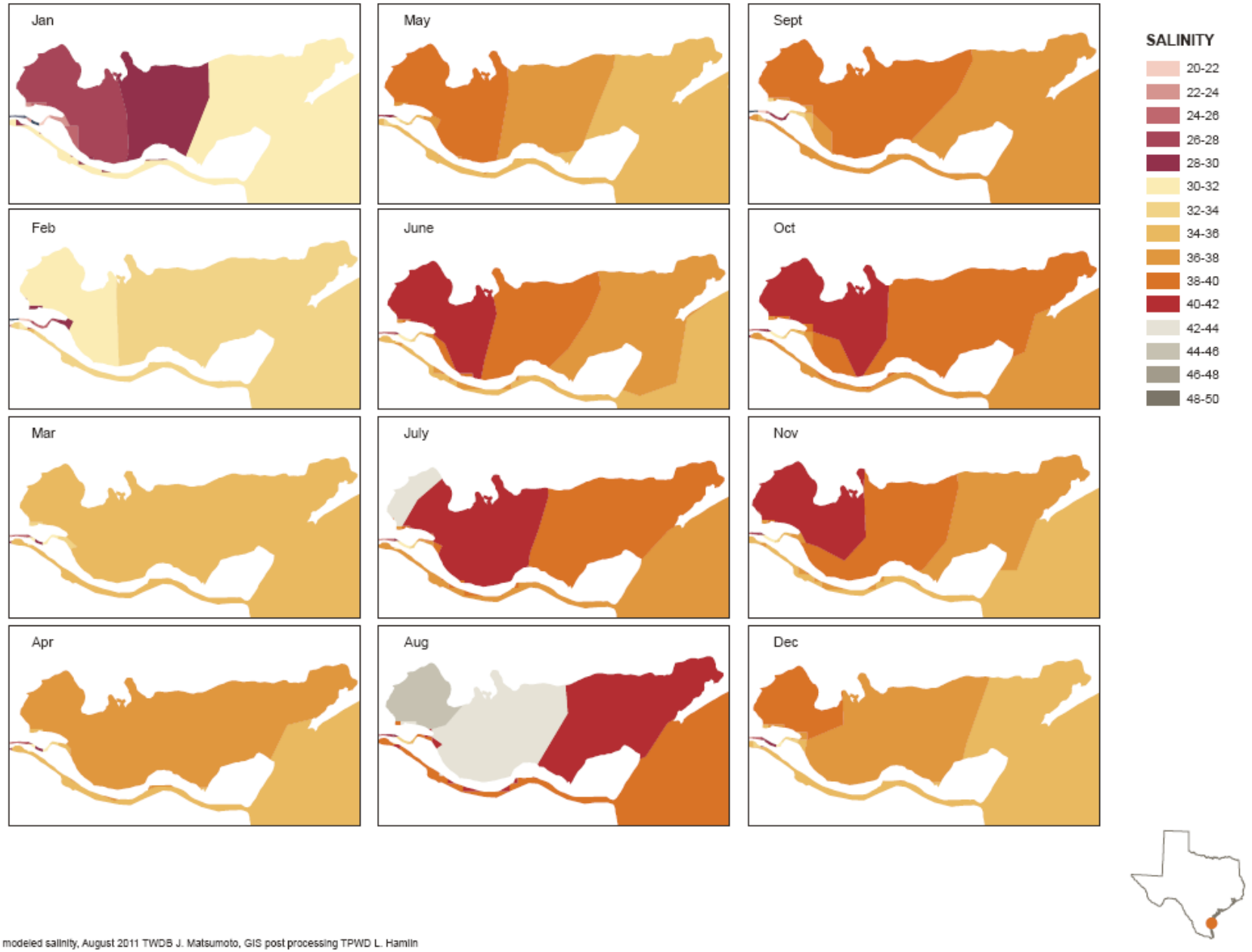
- The allocation for seasonal inflow requirements were based on meeting the biological needs of all indicator species, while accounting for historical patterns of water availability.

- Attainment recommendations were based on historical inflow patterns and how often these conditions were met taking into consideration flow regime changes pre and post dam flows.

TXBLEND Nueces Bay average annual salinity

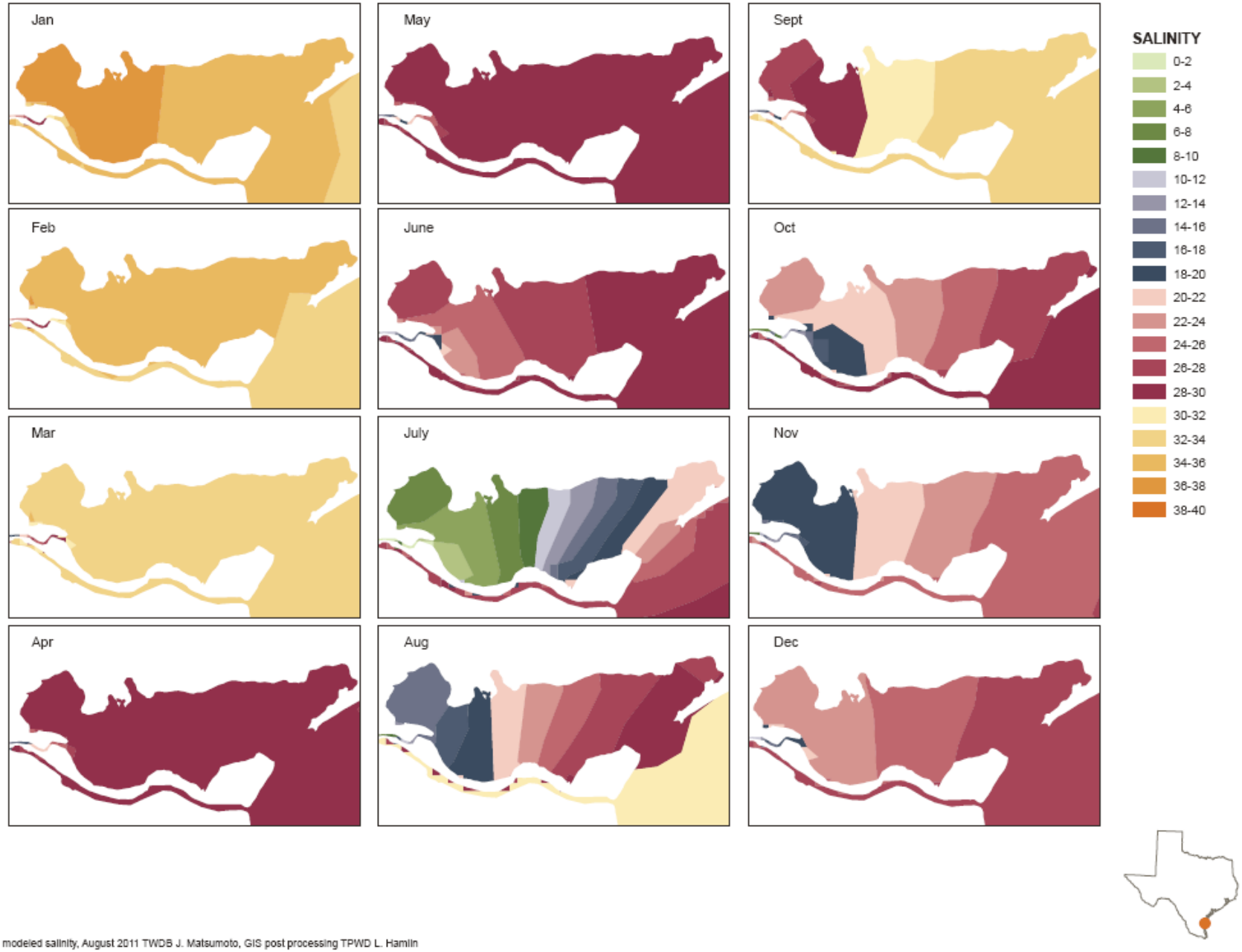


TxBLEND modeled salinity, August 2011 TWDB J. Matsumoto, GIS post processing TPWD L. Hamlin



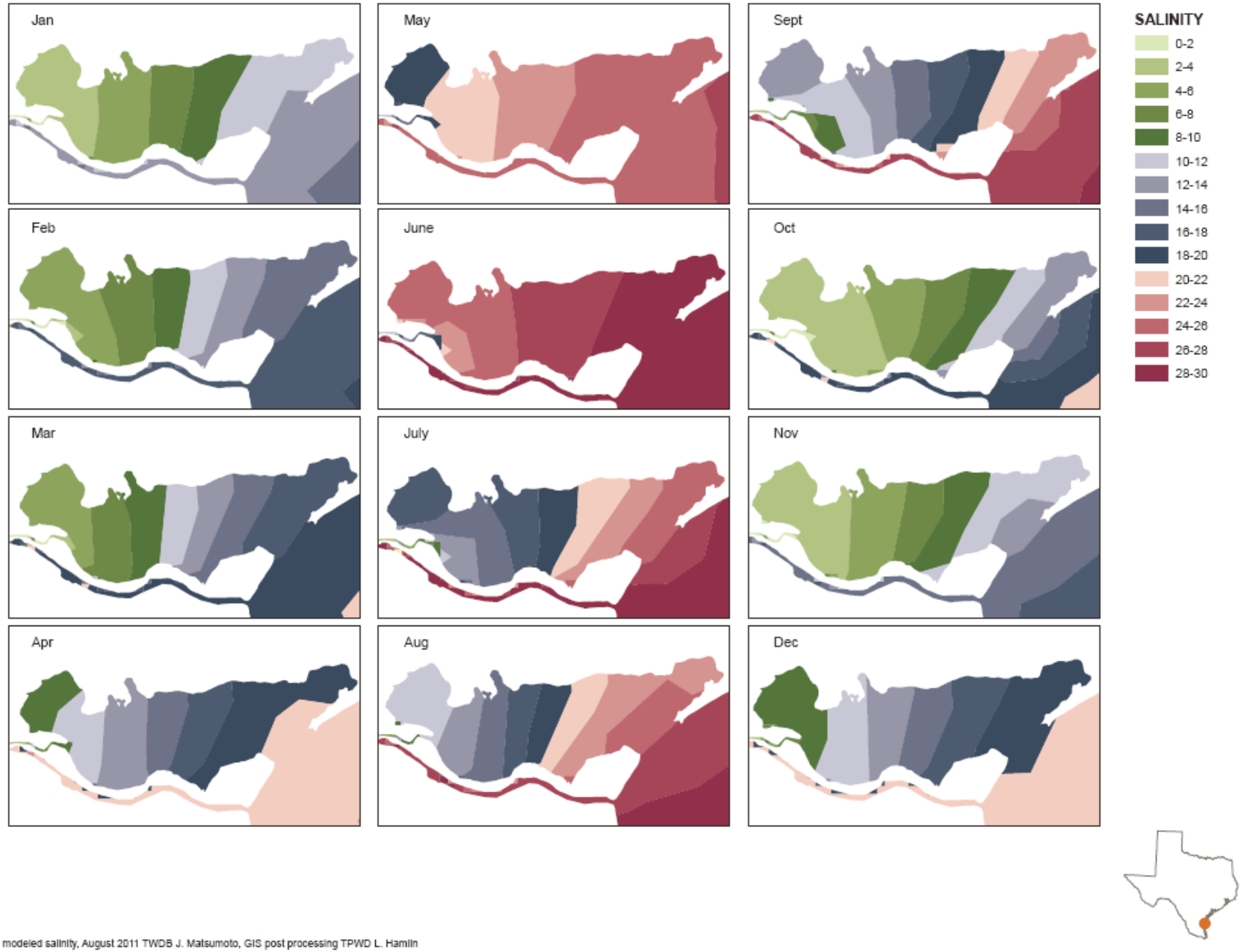
TxBLEND modeled salinity, August 2011 TWDB J. Matsumoto, GIS post processing TPWD L. Hamlin

Appendix X. TXBLEND Nueces Bay dry year 1996



TxBLEND modeled salinity, August 2011 TWDB J. Matsumoto, GIS post processing TPWD L. Hamlin

Appendix X. TXBLEND Nueces Bay Average year 1997



TxBLEND modeled salinity, August 2011 TWDB J. Matsumoto, GIS post processing TPWD L. Hamlin

Appendix X. TXBLEND Nueces Bay wet year 2003

Condition (Target Salinity)	Nueces Estuary Freshwater Inflow Regime (Acre-Feet)												Recommendations		Historical Attainment		
	1 over-banking event per year: 3000 acre-ft (500 acre-ft per day for 6 days)												Annual Total	Attainment	1941-2009	1941-1982	1983-2009
High (10)	125,000 Acre-ft				250,000 Acre-ft				375,000 Acre-ft				750,000	25%	22%	26%	26%
Base (18)	22,000 Acre-ft				90,000 Acre-ft				60,000 Acre-ft				172,000	80%	67%	81%	44%
Subsistence (34)	5,000 Acre-ft				10,000 Acre-ft				15,000 Acre-ft				30,000	95%	94%	100%	85%
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct					
	Winter				Spring				Summer			Fall					

	Nueces River Flow (Acre-ft)			
Nueces Delta Porewater Target Salinity	22,000 (244/day)	90,000 (1000/day)	40,000 (444/day)	20,000 (222/day)
25	**Winter**	**Spring**	**Summer**	**Fall**

- We set target salinities based on indicator species salinity requirements for base condition. We then used TXBLEND model outputs for target salinities that correspond with high and subsistence conditions.

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$$\text{Salinity} = 66.183 - (11.690 \times \text{Log}_{10}(\text{Inflow}))$$

- The allocation for seasonal inflow requirements were based on meeting the biological needs of all indicator species, while accounting for historical patterns of water availability.

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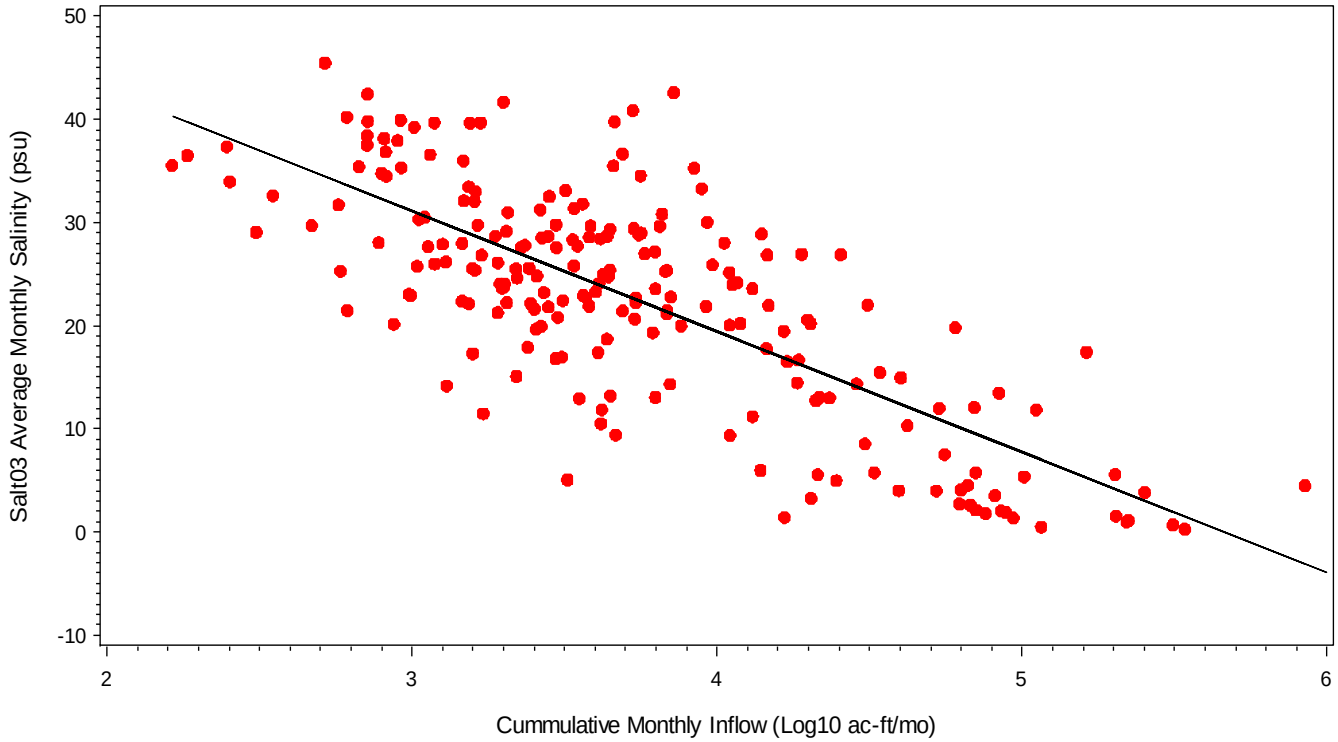
Cumulative inflow vs. salinity using Calallen gauge 1990-2009 and SALT03 station



Salinity = 66.183 - (11.690 * Log10(Inflow)), R^2=0.58

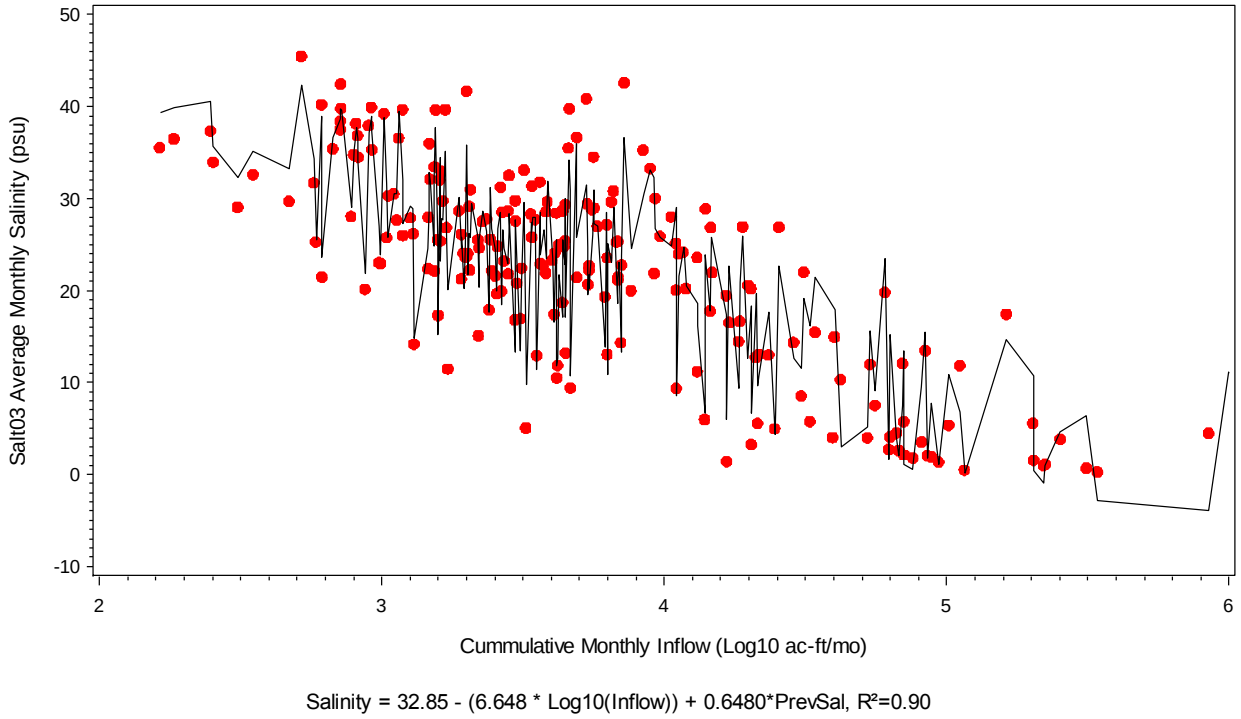


Figure X. SALT03 log cumulative flow vs salinity Calallen gauge with antecedent flow

Condition (Target Salinity)	Nueces Estuary Freshwater Inflow Regime (Acre-Feet)												Recommendations		Historical Attainment		
	1 over-banking event per year: 3000 acre-ft (500 acre-ft per day for 6 days)												Annual Total	Attainment	1941-2009	1941-1982	1983-2009
High (10)	125,000 Acre-ft				250,000 Acre-ft				375,000 Acre-ft				750,000	25%	22%	26%	26%
Base (18)	22,000 Acre-ft				90,000 Acre-ft				60,000 Acre-ft				172,000	80%	67%	81%	44%
Subsistence (34)	5,000 Acre-ft				10,000 Acre-ft				15,000 Acre-ft				30,000	95%	94%	100%	85%
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct					
	Winter				Spring				Summer			Fall					

	Nueces River Flow (Acre-ft)			
Nueces Delta Porewater Target Salinity	22,000 (244/day)	90,000 (1000/day)	40,000 (444/day)	20,000 (222/day)
25	**Winter**	**Spring**	**Summer**	**Fall**

- We set target salinities based on indicator species salinity requirements for base condition. We then used TXBLEND model outputs for target salinities that correspond with high and subsistence conditions.

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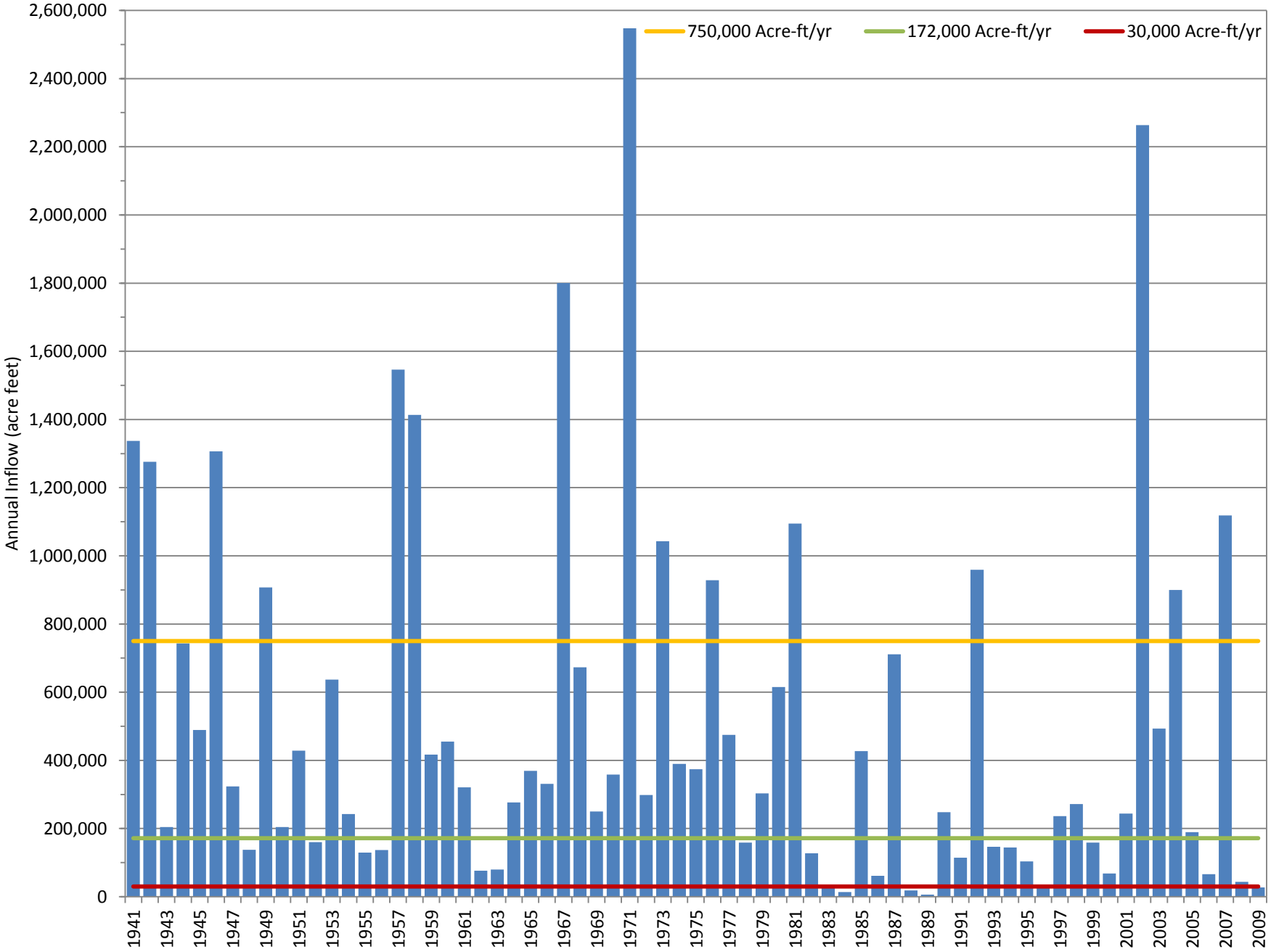
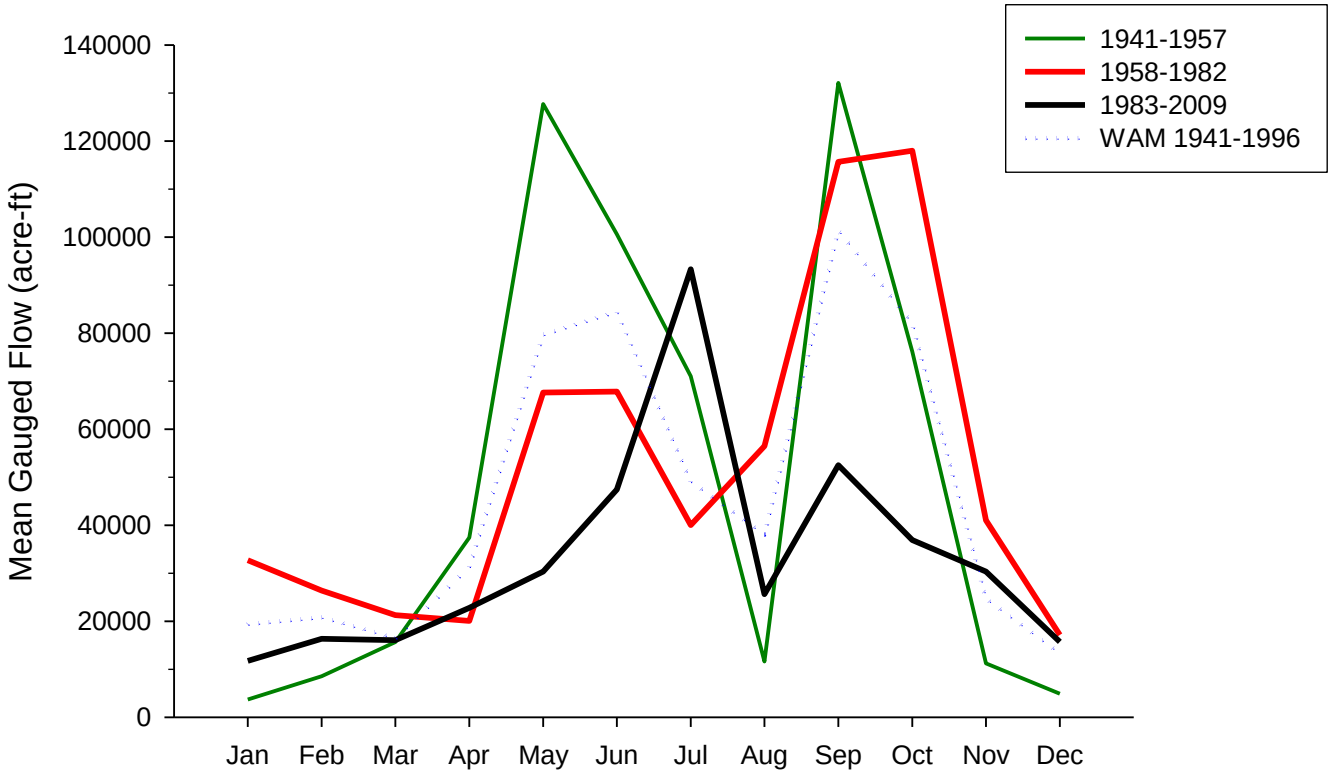
Nueces Bay inflow - recommendation




Mean Gauged Flow (acre-ft)
140000
120000
100000
80000
60000
40000
20000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1941-1957
1958-1982
1983-2009
WAM 1941-1996

Condition (Target Salinity)	Nueces Estuary Freshwater Inflow Regime (Acre-Feet)												Recommendations		Historical Attainment		
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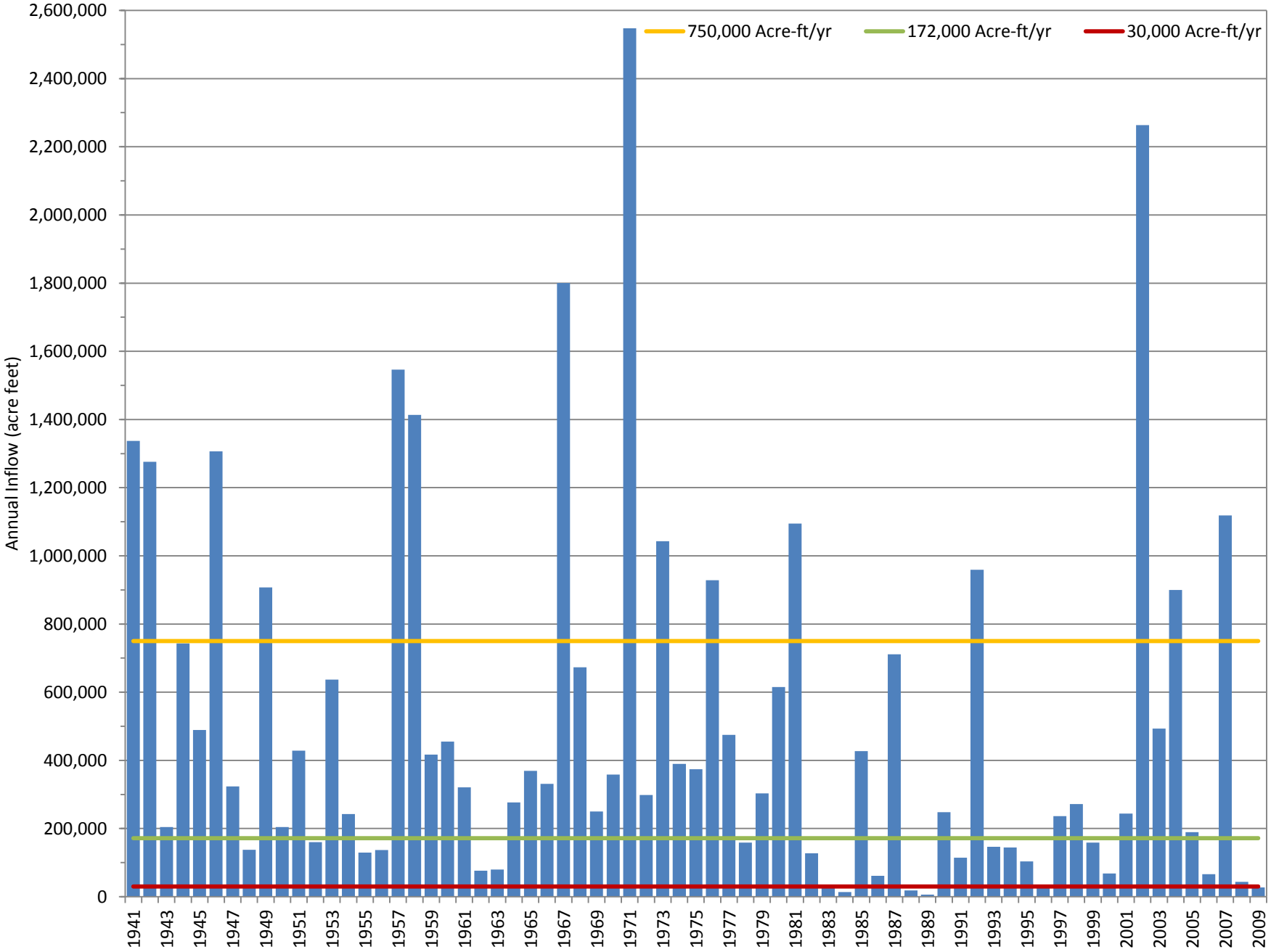
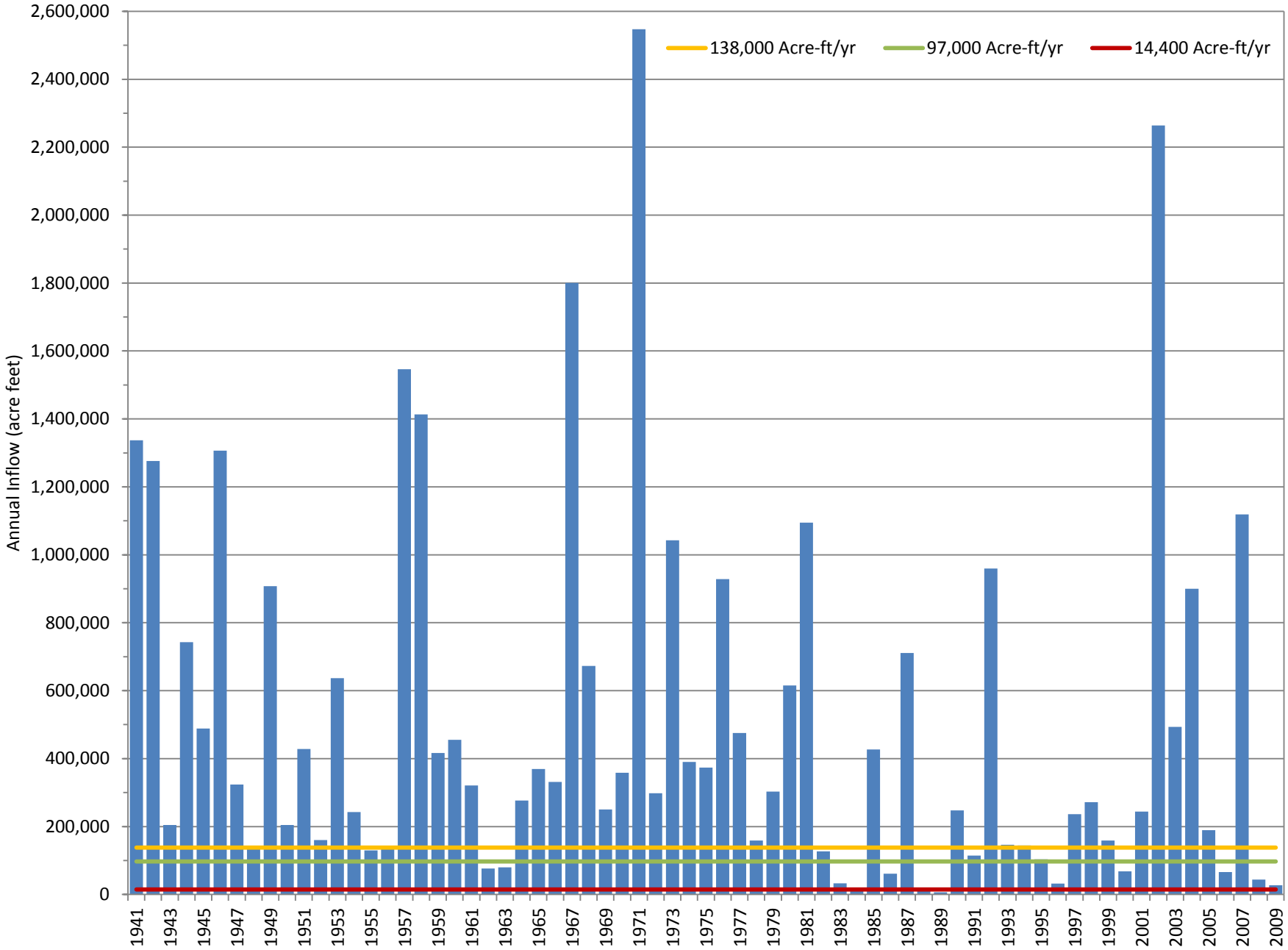
- Attainment recommendations were based on historical inflow patterns and how often these conditions were met taking into consideration flow regime changes pre and post dam flows.

Nueces Bay inflow - recommendation



Nueces Bay inflow – agreed order



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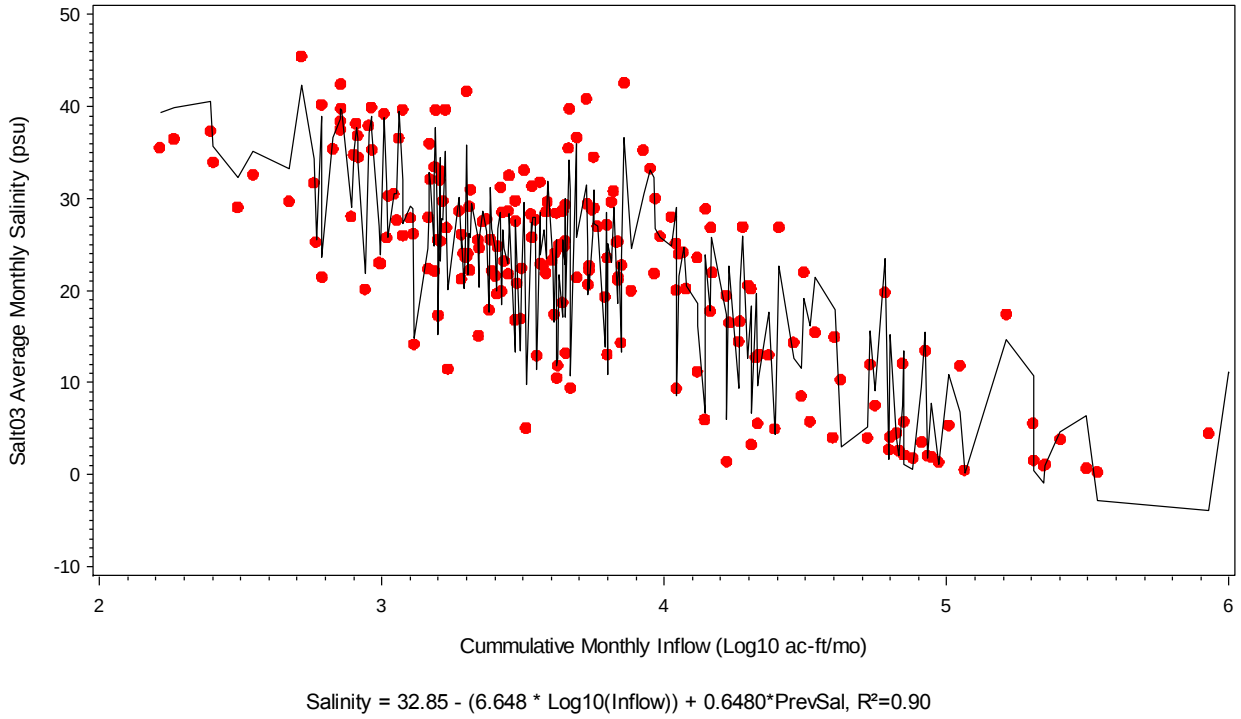
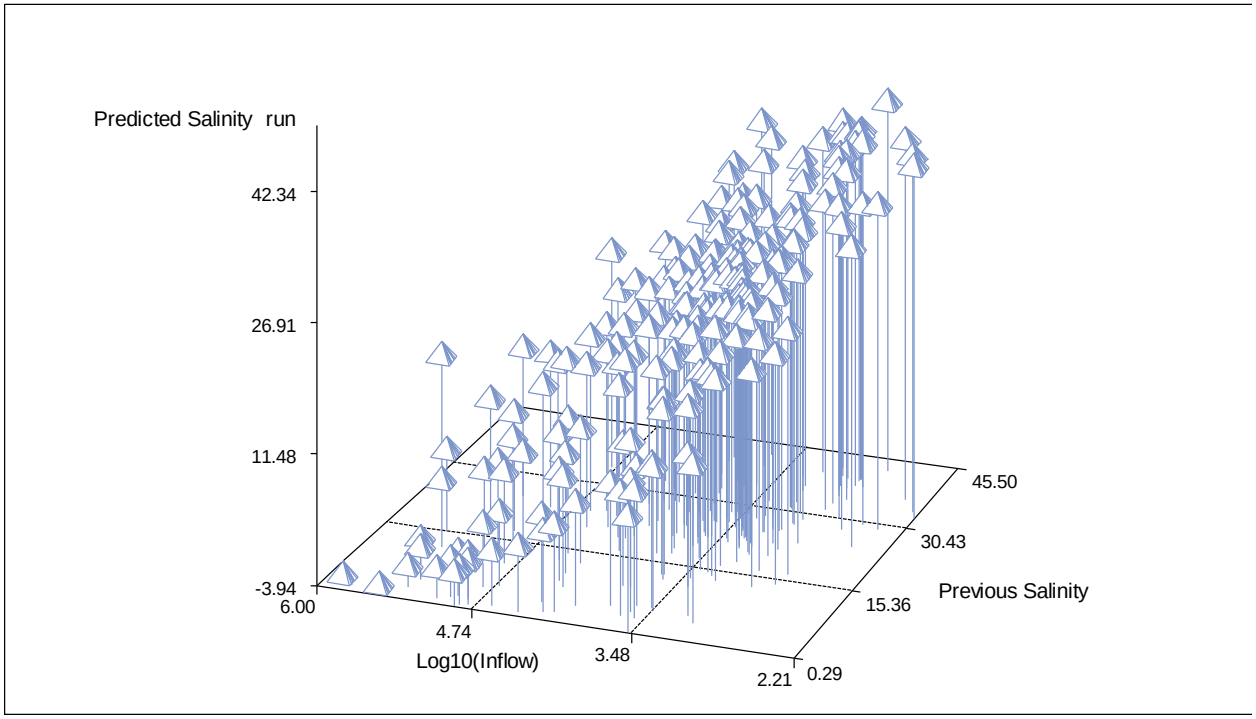
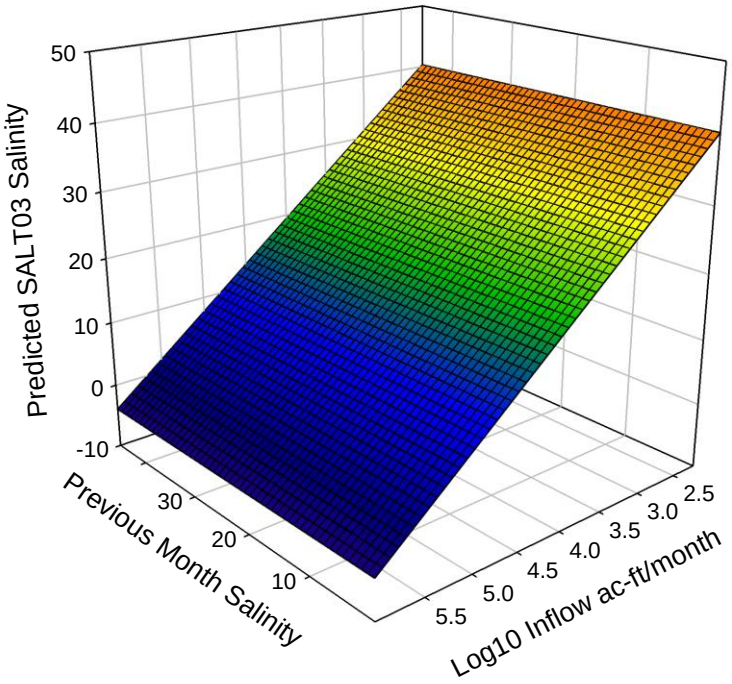


Figure X. SALT03 log cumulative flow vs salinity Calallen gauge with antecedent flow



Appendix X. SALT03 log cumulative flow vs salinity Calallen gauge with antecedent flow

SALT03



Appendix X. SALT03 log cumulative flow vs salinity Calallen gauge with antecedent flow nomogram